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The social value of prehistoric axes – new archaeological and archaeometric approaches

16. Mitteldeutscher Archäologentag vom 5. bis 7. Oktober 2023 in Halle (Saale)

Herausgeber Roberto Risch, Ernst Pernicka und Harald Meller

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LANDESMUSEUM FÜR VORGESCHICHTE

herausgegeben von
Roberto Risch,
Ernst Pernicka und
Harald Meller

Halle (Saale)
2024

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Geleitwort/*Foreword*

Dear Professor Meller, dear members of the local organising team, and, above all, dear guests:

Welcome!

Welcome here in Halle, and, especially on this evening, welcome to the 16th Central German Archaeological Conference at Martin-Luther-University in Halle-Wittenberg! Almost one year ago today I had the pleasure to welcome the participants of your 15th congress here in Halle. And I very much enjoy giving this opening address on this very occasion now. Good to have you here with us!

As I learned, we have a very international audience today, with scientists from at least 10 different countries who have come together to discuss various aspects around the topic of the social value of prehistoric axes. Quite an interesting topic indeed, since the social value might not be the first thought one has when reflecting on an instrument such as an axe.

So let me share with you my personal reflections when thinking about axes in the context of the wide range of subjects offered at our university:

- It takes the idea of an axe to produce an axe: here, we might be in the field of innovation in the widest sense.
- It takes time to produce an axe: we might think of production processes, but also of the human resources necessary for this purpose.
- It takes material resources to produce an axe: thus knowledge of material sciences but also logistics must be considered in this context.
- Depending on the materials used, it might take money or other valuables to produce an axe: this encompasses the fields of commerce and exchange, but also social contacts.
- To know how to use the materials, it takes knowledge: this requires education.
- To get new resources, it might take a system of trading: more social contacts, probably even a sort of globalisation, are implied.
- Or it might require intelligent approaches to salvage material resources: recycling.
- And, finally, when you've got the axe, there are the occasions to use it, and you might also have to be concerned about the consequences of its use – cutting down a tree (is this sustainable?), defending oneself against an enemy (do we go down the path of war or try to achieve peace?), representing one's importance, being honoured by society – even on the occasion of one's funeral (finally: social value!).

Lieber Professor Meller, liebes Organisationsteam und vor allem liebe Gäste,

Willkommen!

Herzlich willkommen hier in Halle und ganz besonders heute Abend an der Martin-Luther-Universität Halle-Wittenberg zum 16. Mitteldeutschen Archäologentag! Es ist fast auf den Tag genau ein Jahr her, dass ich das Vergnügen hatte, die Teilnehmer des 15. Archäologentags hier in Halle begrüßen zu dürfen. Es ist mir eine Freude, auch zum aktuellen Anlass das Grußwort beizusteuern. Es ist schön, dass Sie hier bei uns sind!

Wie ich erfahren habe, ist unser Publikum heute sehr international, mit Wissenschaftlern aus mindestens zehn verschiedenen Ländern, die zusammengekommen sind, um die unterschiedlichen Aspekte des sozialen Werts prähistorischer Äxte und Beile zu diskutieren. Das Thema ist recht interessant, zumal man bei einem Instrument wie einer Axt nicht unbedingt als Erstes an seinen sozialen Wert denkt.

Aus diesem Grund möchte ich meine eigenen Überlegungen mit Ihnen teilen, wie das Thema dieser Tagung zu den an unserer Universität vertretenen Fächern passt:

- Um eine Axt oder ein Beil herzustellen, bedarf es der Idee davon. Dies bringt uns in den Bereich der Innovation im weitesten Sinne.
- Zur Herstellung benötigt man Zeit. Wir denken an Produktionsprozesse, aber auch an die dazu notwendigen menschlichen Ressourcen.
- Zur Herstellung braucht es Materialressourcen. Man benötigt Kenntnisse der Materialwissenschaften, muss in diesem Zusammenhang aber auch die Logistik bedenken.
- Je nach den verwendeten Materialien braucht man für die Herstellung Geld oder andere Wertgegenstände. Das bringt uns in die Bereiche von Handel, Tausch und sozialen Kontakten.
- Man muss außerdem wissen, wie das Material zu verwenden ist. Hierzu braucht es Bildung.
- Um neue Ressourcen zu erschließen, braucht es womöglich ein Handelssystem, also soziale Kontakte und vermutlich sogar eine Art von Globalisierung.
- Oder man benötigt intelligente Ansätze, um die Materialressourcen wiederzuverwenden, das heißt zu recyceln.
- Und wenn man schließlich eine Axt oder ein Beil hat, muss man auch Gelegenheit zum Gebrauch haben und sich unter Umständen mit den Konsequenzen desselben auseinandersetzen. Ich denke an das Fällen von

Obviously, by investigating the world of axes, it is possible to investigate

- the world of an early economy including production, innovation, commerce; even a sort of circular economy with at least the aspects of reuse and recycling – hence early aspects of, say, a sort of sustainability,
- the world of social life: social cohesion, social clash, structural breaks in societies – hence aspects of transformation,
- and, finally, the world of knowledge transfer within one group or society and between different societies as well as across generations – hence aspects of knowledge cultures and education.

This fits perfectly well into the main scientific profile our university stands for: transformation, knowledge cultures, and education, but also – though to a lesser degree – sustainability.

So – with all the more reason – we welcome you here with us. I wish you all the best for your conference. Have a good time at our university and a good time here in Halle!

Prof. Dr. Claudia Becker
Rector, Martin Luther University Halle-Wittenberg

Bäumen (ist das nachhaltig?), daran, sich gegen einen Feind zu verteidigen (sind wir auf Krieg oder Frieden aus?), an die Darstellung der eigenen Bedeutung und daran, von der Gesellschaft geehrt zu werden – selbst bei der eigenen Bestattung (endlich: der soziale Wert!).

Wenn man Äxte und Beile untersucht, ist offensichtlich auch die Betrachtung folgender Aspekte möglich:

- frühe Wirtschaftsstrukturen, einschließlich Produktion, Innovation, Handel und sogar eine Art Kreislaufwirtschaft, die zumindest die Aspekte von Wiederverwendung und Wiederverwertung und damit auch eine Art von Nachhaltigkeit beinhaltet,
- das Sozialleben, das heißt gesellschaftlicher Zusammenhalt, soziale Konflikte, strukturelle Umbrüche in Gesellschaften und damit Aspekte der Transformation sowie
- eben auch die Welt des Wissenstransfers innerhalb einer Gruppe oder Gesellschaft und zwischen verschiedenen Gesellschaften und über Generationen hinweg – daher Aspekte von Wissenskulturen und Bildung.

Das passt perfekt in das wissenschaftliche Profil unserer Universität: Transformation, Wissenskulturen und Bildung und – zwar in geringerem Maße, aber unleugbar – auch Nachhaltigkeit.

In diesem Sinne heiße ich Sie erst recht hier bei uns herzlich willkommen und wünsche Ihnen alles Gute für diese Tagung. Genießen Sie die Zeit an unserer Universität und hier in Halle.

Prof. Dr. Claudia Becker
Rektorin der Martin-Luther-Universität Halle-Wittenberg

Produktion, Verbreitung und Gebrauch. Die Macht von Äxten und Beilen vom Neolithikum bis zur Bronzezeit/ *Production, distribution, and use. The power of axes between the Neolithic and the Bronze Age*

Roberto Risch, Ernst Pernicka und Harald Meller

Beile und Äxte gehören zu den wenigen Artefaktgruppen, die es uns gestatten, unser wirtschaftliches Denken bis in die Antike zurückzuverfolgen – und gleichzeitig zu hinterfragen. Obwohl geschliffene und polierte Beilklingen in vielen Teilen Europas seit dem Mesolithikum bekannt waren, wurden sie mit Beginn des Neolithikums zu einem unverzichtbaren Werkzeug für Gesellschaften, die in Landschaften mit dichter Vegetation Ackerbau betrieben, in Häusern mit Holzkonstruktion lebten oder Holz bearbeiteten, um spezielle Artefakte wie Boote herzustellen.

Spätestens seit Aristoteles (Politica, 336–323 v. Chr.) ist die Vorstellung von Wirtschaft mit dem Konzept des Gebrauchswerts verbunden. Ganz allgemein werden Tätigkeiten, die nützliche Dinge hervorbringen, in einer Gesellschaft als von Wert betrachtet. Für Aristoteles war Land die Hauptquelle des Wohlstands, denn es war Grundlage von Ackerbau und Viehzucht. Schon bald jedoch wurden Äxte nicht mehr nur als Werkzeuge, sondern auch als Waffen verwendet (vgl. Beiträge Hansen; Bonora Soriano; Peres u. a. in diesem Band). Anthropologische Untersuchungen an menschlichen Überresten belegen unzweideutig die Gewalt, die mit Stein- und Metalläxten und -beilen ausgeübt wurde. Prominente Beispiele dafür sind die Schädel aus der frühneolithischen Grabenanlage von Herxheim, Lkr. Südliche Weinstraße, die bandkeramischen Massengräber von Halberstadt, Lkr. Harz (Meyer u. a. 2015; Meyer u. a. 2018), und Talheim, Lkr. Heilbronn (Wahl/König 1987), das schnurkeramische Massengrab von Eulau, Lkr. Burgenlandkreis (Haak u. a. 2008), und der kupferzeitliche Schädel aus der Höhle von Pas-de-Julié, Dep. Gard (Costantini 2002, 141)[1].

Von Anfang an waren Äxte und Beile jedoch viel mehr als nur Werkzeuge und Waffen. Die begrenzte Zahl an Vorkommen mit Gesteinen und Mineralien, die als Rohmaterial dienen konnten, führte zu einer unmittelbaren Entstehung von Vertriebsnetzen zwischen den Gemeinschaften. Obwohl sich schon Aristoteles der Idee vom *Tauschwert* bewusst war, erkannte erst A. Smith (1776) sehr viel später, dass *Tauschwert* im Gegensatz zu *Gebrauchswert* mit der menschlichen Arbeitskraft, die in die Herstellung eines Gegenstands hineingeflossen war, zusammenhängen musste. D. Ricardo (1817) führte diese Theorie der klassischen Ökonomie näher aus; das Ergebnis war die analytische Reduktion des Tauschwerts auf den Arbeitsaufwand, der in Zeiteinheiten gemessen und mit einem bestimmten Produkt in Verbindung gebracht

1 Zusammenfassend zu Krieg im Neolithikum mit besonderem Schwerpunkt auf Kampfverletzungen Schefzik 2015; Meller/Dietl 2021.

Axes belong to the select groups of artefacts that allow us to trace back in time – yet simultaneously question – our economic thinking since Antiquity. Although polished axeheads were known since the Mesolithic in many parts of Europe, with the beginning of the Neolithic they became an indispensable tool for societies practicing agriculture in landscapes with dense vegetation, living in houses with wooden structures, or working dry wood in order to obtain specific artefacts, such as boats.

At least since Aristotle (Politica, 336–323 BC) the idea of an economy has been linked to the concept of *use value*. Generally, the activities that provide useful things should be considered as being of value in a society. The primary source of wealth for Aristotle was land, which facilitated the development of agriculture and husbandry. However, very soon axes also were used as weapons (cf. Hansen; Bonora Soriano; Peres et al. in this volume). The anthropological remains show with little ambiguity the violence perpetuated with both stone and metal axes. Prominent examples include the skulls of the Early Neolithic funerary structure of Herxheim, Südliche Weinstraße district, the Linear Pottery mass graves of Halberstadt, Harz district (Meyer et al. 2015; Meyer et al. 2018), and Talheim, Heilbronn district (Wahl/König 1987), the Corded Ware mass grave at Eulau, Burgenlandkreis district (Haak et al. 2008), or the Copper Age skull found in the cave of Pas-de-Julié, Dep . Gard (Costantini 2002, 141)[1].

Since the beginning, axes were generally much more than tools and weapons. The limited number of raw material occurrences with rocks and minerals that could be transformed into axes immediately fostered the rise of distribution networks between communities. Although Aristotle was already aware of the notion of *exchange value,* it was only much later that A. Smith (1776) recognised that the *exchange value* as opposed to *use value* had to be related to the human labour invested in the manufacturing of a given object. D. Ricardo (1817) elaborated this theory of classical economy further: The analytical reduction of exchange value to the amount of labour that could be measured in units of time and incorporated into a given product was the result. K. Marx (1867) insisted on the dialectical relationship existing between such an exchange value and the use value in capitalist economy, thereby establishing the conceptual unity between production and consumption. Moreover, he was the first to fully acknowledge the importance of the

1 Summarising warfare in the Neolithic with a special focus on combat injuries Schefzik 2015; Meller/Dietl 2021.

werden konnte. K. Marx (1867) bestand auf der dialektischen Beziehung zwischen dem Tauschwert und dem Gebrauchswert in der kapitalistischen Wirtschaft und stellte damit die konzeptuelle Einheit zwischen Produktion und Konsum her. Darüber hinaus war er der Erste, der die Bedeutung der Produktionsmittel in der wirtschaftlichen Entwicklung *(konstantes Kapital)* als von der Arbeitskraft *(variables Kapital)* separaten Faktor, aber mit direkten Auswirkungen auf den Wert aller Produkte in einer Gesellschaft, voll anerkannte.

Dabei hat die seit Ende des 19. Jhs. vorherrschende akademische Denkweise des *Marginalismus* die Suche nach einer Definition von Wert als etwas anderem als Preis faktisch aufgegeben. Das Konzept vom Grenzwert betrachtet lediglich die relativen Unterschiede zwischen Waren, die sich aus einem angeblichen Gegensatz zwischen ihrer »begrenzten« Quantität und dem Bedarf des Individuums in »noch so weite[n] Grenzen« ergeben (Menger 1871 [1971], 237). Da der einzige objektive Ausdruck dieses Vergleichs der tatsächliche Preis von Waren ist, ist die Theorie zwangsläufig tautologisch und entbindet die ökonomische Analyse von der Betrachtung der materiellen und historischen Bedingungen, unter denen die Produktion stattfand[2]. Die marginalistische Reduktion des Wertbegriffs auf den Bereich subjektiven Begehrens und Bedürfnisses ermutigte die Gesellschaftswissenschaften dazu, die Diskussion über den Wert in eine Untersuchung der vielfältigen Möglichkeiten zu lenken, wie Individuen ihre Beziehungen zu anderen bewerten (Simmel 1900; Appadurai 1986; Humphrey/Hugh-Jones 1992) oder das Konzept in der Überzeugung gänzlich aufzugeben, dass es unmöglich sei, eine simple analytische Definition für ›Wert‹ zu finden. Die Entwicklung der Wirtschaftstheorie beweist, dass es vermutlich ein Fehler ist, versuchen zu wollen, jegliche Vorstellung von *Tauschwert* auf einen einzigen ökonomischen Faktor wie die Arbeitskraft zu reduzieren. Der soziale Wert von Beilen und Äxten ergab sich möglicherweise aus vielen anderen sozialen Beziehungen (vgl. Beiträge Klimscha; Sheridan; Giligny; Brunet; Rodríguez-Rellán/Fabregas Valcare; Dietrich u. a. in diesem Band).

Die größte theoretische Schwierigkeit ist allerdings, dass das von Ricardo und Marx, aber auch vom *Marginalismus* vorgebrachte Konzept vom Tauschwert nur in einer Marktwirtschaft relevant ist, in der sämtliche Produkte zu Waren geworden sind (Gregory 1982). Um diese historische Spezifizität zu überwinden, gleichzeitig aber auch die Vorstellung aufrechtzuerhalten, dass soziale Objekte eine intentionale energetische und materielle Transformation implizieren, haben wir uns für den Begriff des *Produktionswerts* entschieden (Risch 2002, 28–31). Er beinhaltet, dass alle Objekte/Subjekte, die von einer Gemeinschaft erzeugt und erhalten werden, einen Wert haben, der sich aus dem Herstellungsprozess ergibt, welcher bestimmte Kräfte und Materialien einsetzt. In

2 Die folgenden Aussagen der Begründer der modernen Wirtschaftstheorie drücken diesen Spagat zwischen der materiellen Welt und dem vorgeschlagenen Wertbegriff sehr klar aus: »[I]n einer Gesellschaft, welcher alle Güter in einer ihren Bedarf übersteigenden Menge verfügbar wären, [gäbe es] weder ökonomische Güter, noch auch ›Vermögen‹« (Menger 1871, 72); »Nützliche Dinge, die nicht knapp sind, sind nicht Teil des sozialen Wohlstands« (Walras 1874 [1952], 21 ff.).

means of production in economic development *(constant capital)* as a factor separate from labour force *(variable capital)* but with direct repercussions for the value of all products in a society.

Meanwhile, the dominant academic thought since the end of the 19th century, known as *marginalism*, has in practice abandoned the search for a definition of value as something different from price. The concept of marginal value considers only the relative differences between commodities resulting out of an alleged opposition between their »scarcity« and the »unlimited necessities« of the individual (Menger 1871 [1971], 237). As the only objective expression of this comparison is the actual price of commodities, the theory is inevitably tautological and releases economic analysis from considering the material as well as historical conditions in which production took place[2]. The marginalist reduction of the notion of value to the realm of subjective desires and necessities encouraged social sciences to drive the discussion of value into an examination of the multiple ways individuals judge their relations with others (Simmel 1900; Appadurai 1986; Humphrey/Hugh-Jones 1992), or to abandon the concept altogether in the conviction that it is impossible to find an easy analytical definition for ›value‹. The development of economic theory shows that it is probably a mistake to try to reduce any notion of *exchange value* to one single economic factor, such as labour force. The social value of axes possibly resulted from many other social relationships (cf. Klimscha; Sheridan; Giligny; Brunet; Rodríguez-Rellán/Fabregas Valcare; Dietrich et al. in this volume).

The main theoretical difficulty, however, is that the concept of exchange value advanced by Ricardo and Marx, but also by *marginalism*, is only relevant in a market economy, where all products have become commodities (Gregory 1982). In order to overcome this historical specificity but at the same time to maintain the notion that social objects imply an intentional energetic and material transformation, we have chosen the concept of *production value* (Risch 2002, 28–31). It implies that all objects/subjects generated and maintained by a community have a value resulting out of a production process that puts into action specific forces and materials. In this sense, it is not only the social objects but also the actions that generate and maintain them that must be considered as valuables (Graeber 2001, 45 ff.). The dialectical relation between *production value* and *use value* can be expressed by the term *social value* as the ever-changing synthesis between production and consumption processes.

Basically, it can be proposed that the production value depends on a series of natural and social constraints, which can be addressed through different archaeological, archaeometric, geoarchaeological, experimental, mechanical, and ethnoarchaeological procedures (Risch 2011):

2 The following statements of the founders of modern economic theory express very clearly this split between the material world and the proposed notion of value: »In a society which disposes of all types of goods always above their needs, there would be no economic goods nor wealth« (Menger 1871 [1985], 97 ff.); »Useful things which are not scarce do not form part of the social wealth« (Walras 1874 [1952], 21 ff.).

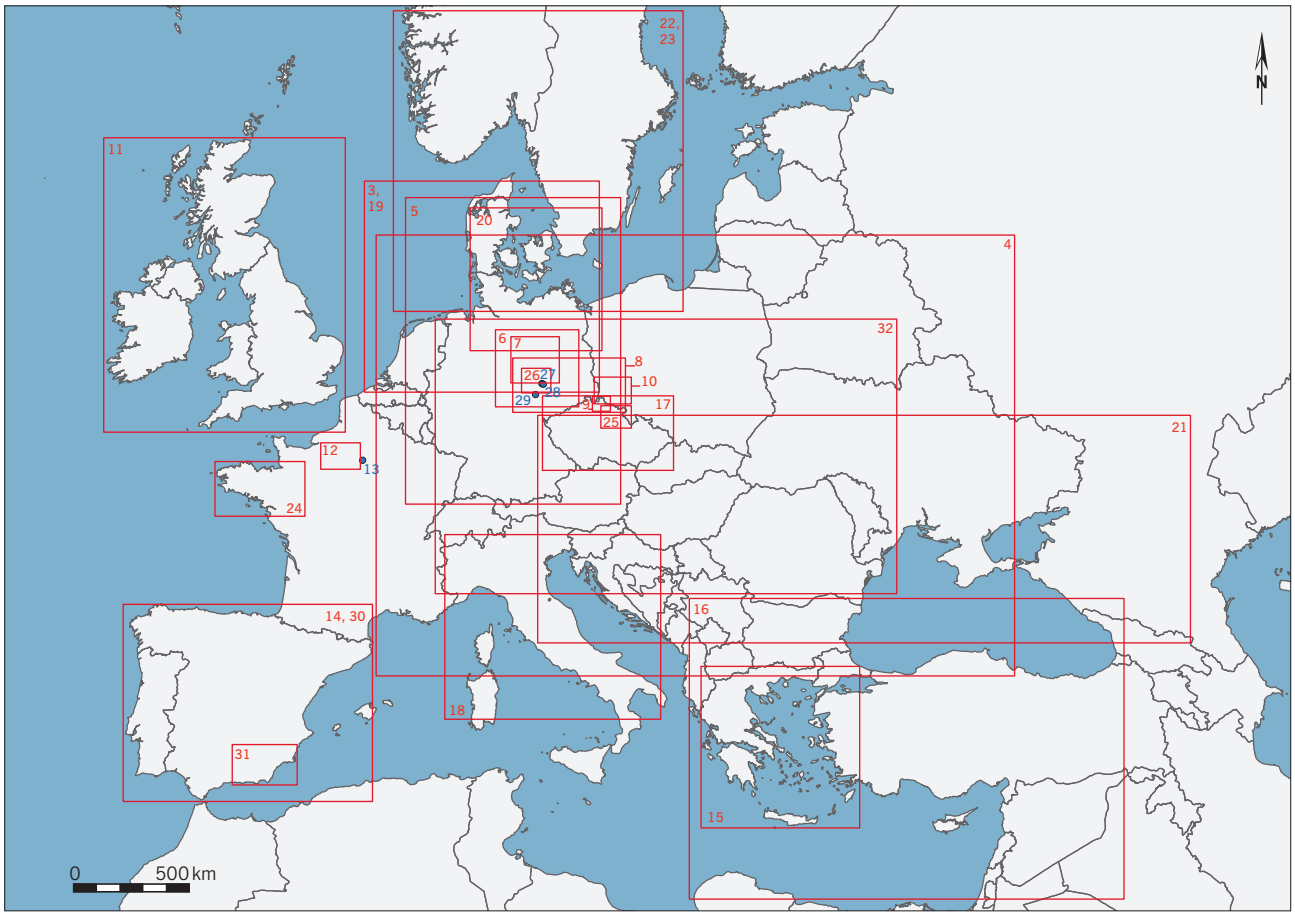

Abb. 1 Karte der in diesem Band behandelten Regionen. Die Nummerierung entspricht der Reihenfolge der Beiträge im Band.

Fig. 1 *Map showing the regions discussed in this volume. The numbering corresponds to the order of contributions in this volume.*

3 Sørensen/Bendtsen; 4 Klimscha; 5 Müller; 6 Beran; 7 Beran u. a.; 8 Meinecke et al.; 9 Šída/Burger; 10 Borowski et al.; 11 Sheridan; 12 Giligny; 13 Brunet; 14 Rellán/Fabregas; 15 Chondrou; 16 Dietrich et al.; 17 Dobeš; 18 Dolfini; 19 Müller et al.; 20 Skorna; 21 Hansen; 22 Nørgaard; 23 Melheim; 24 Le Carlier de Veslud/Révillon; 25 Schimerová et al.; 26 Michael et al.; 27 Berger et al.; 28 Bunnefeld u. a.; 29 Dalidowski u. a.; 30 Peres et al.; 31 Bonora Soriano; 32 Dietrich.

diesem Sinne sind es nicht nur die sozialen Objekte, sondern auch die Vorgänge, durch die sie erschaffen und beibehalten werden, die als wertvoll betrachtet werden müssen (Graeber 2001, 45 ff.). Die dialektische Beziehung zwischen *Produktions-* und *Gebrauchswert* kann durch den Begriff *sozialer Wert* ausgedrückt werden: die sich laufend verändernde Synthese von Produktions- und Konsumationsprozessen.

Im Grunde kann eine Abhängigkeit des *Produktionswerts* von einer Reihe von natürlichen und sozialen Einschränkungen bestehen, die durch verschiedene archäologische, archäometrische, geoarchäologische, experimentelle und ethnoarchäologische Verfahren beleuchtet werden können (Risch 2011):

1. Die Zugänglichkeit natürlicher Ressourcen

Da diese Zugänglichkeit sowohl natürlich als auch sozial begrenzt sein kann, hängt der Wert der Rohmaterialien und damit der des Endprodukts sicherlich von den ökologischen und sozialen Bedingungen ab, unter denen der Abbau geschieht. Situationen von Autonomie im Gegensatz zu Abhängigkeit, von uneingeschränktem Zugang oder aber einem Monopol und von Konkurrenz gegenüber dem Teilen wirken sich unterschiedlich auf Produktion und Konsum aus.

1. The accessibility of natural resources

As this accessibility can be limited naturally as well as socially, the value of raw materials and hence of the final products certainly depends on the environmental and social conditions in which their exploitation takes place. Situations of autonomy as opposed to dependency, of unrestricted access as opposed to monopoly, or of competition versus sharing have different effects on production as well as on consumption.

- In the case of axes, the question of the *accessibility* of rock and ore occurrences requires provenance studies as well as a consideration of the implications of the exploitation of different resources and environments. Crucial differences exist, for example, between primary and secondary deposits in the way rocks are exploited and social access can be restricted. The *dependency* of a society with respect to raw materials suitable for producing axes depends on the material and technical choices available. Here, it is particularly important to determine the variety of rocks available in each region or territory (cf. Meinecke et al.; Šída/Burgert; Borowski et al.; Chondrou in this volume). Copper deposits are primarily located in mountain-

- Im Falle von Äxten und Beilen erfordert die Frage nach der *Zugänglichkeit* von Gesteins- und Erzvorkommen sowohl Herkunftsuntersuchungen als auch Überlegungen zu den Auswirkungen der Ausbeutung verschiedener Ressourcen und Umgebungen. Beim Gesteinsabbau und der gesellschaftlichen Beschränkung des Zugangs bestehen beispielsweise bedeutende Unterschiede zwischen primären und sekundären Lagerstätten. Die Abhängigkeit der Gesellschaft im Hinblick auf Rohmaterialien, die sich zur Herstellung von Äxten und Beilen eignen, hängt von den verfügbaren materiellen und technischen Auswahlmöglichkeiten ab. Hier ist es besonders wichtig, die Gesteinsart zu bestimmen, die in der jeweiligen Region oder dem jeweiligen Gebiet zur Verfügung stand (vgl. Beiträge Meinecke u. a.; Šída/Burgert; Borowski u. a.; Chondrou in diesem Band). Kupfervorkommen liegen vorrangig in Gebirgen. Hier ist nicht nur die Zugänglichkeit, sondern auch die Möglichkeit zur Versorgung der Bergleute und die Möglichkeit zur Verhüttung der Erze bei der Zuweisung von Objekten zu einzelnen Produktionszentren zu berücksichtigen (vgl. Beiträge Müller u. a.: Nørgaard; Melheim; Le Carlier de Veslud/Révillon; Berger u. a. in diesem Band).

2. Der Produktionsprozess

Arbeitskraft im energetischen Sinne ist eine Abstraktion der menschlichen Beteiligung an jeglicher wirtschaftlicher Tätigkeit und gleichzeitig die unmittelbare physische Begrenzung, mit der sich alle Gesellschaften konfrontiert sehen. Der Umfang der Arbeitskraft, die für eine bestimmte Produktion nötig ist, beeinflusst deshalb zwangsläufig den Produktionswert der erzeugten Gegenstände oder Dienstleistungen (vgl. Beitrag M. Müller in diesem Band). Beide variieren je nach der wirtschaftlichen Produktivität, die durch technologische Entwicklung, Arbeitsteilung und Umfang der hergestellten Güter erzielt wird.

- Laut experimenteller und ethnografischer Daten stellen Schleifen/Polieren den *arbeitsintensivsten* Teil der Herstellung von Steinbeilen dar, während es bei Metalläxten das Gießen und Schmieden ist (vgl. Beitrag Bunnefeld u. a. in diesem Band). Das Sägen von Gestein ist eine weitere zeitaufwendige Technologie, die allerdings den Vorteil hat, das Rohmaterial viel effizienter zu nutzen als es beim Abschlagen der Fall wäre (vgl. Beitrag Meinecke u. a. in diesem Band). Der Produktionsaufwand kann je nach der Größe der Werkzeuge variieren. Allgemein lässt sich sagen, dass größere Äxte und Beile schwieriger herzustellen sind und mehr Zeit sowie Aufwand fürs Schleifen/Polieren und Schmieden erfordern (vgl. Beitrag Michael u. a. in diesem Band). Bei der Entstehung des Produktionswerts kommt der Größe demnach eine ähnliche Bedeutung zu wie der Herkunft des Rohmaterials (vgl. Beiträge Brunet; Gilligny; Chondrou in diesem Band).

Wenn, aus welchen Gründen auch immer, Rohmaterialien oder Fertigwaren zwischen Menschen im Umlauf sind, entstehen *Tauschwerte* und bringen mindestens zwei verschiedene Wirtschaftspraktiken mit sich:

ous areas. Here, not only the accessibility but also the possibility of supplying the miners and the possibility of smelting the ores must be taken into account when allocating objects to individual production centres (cf. Müller et al: Nørgaard; Melheim; Le Carlier de Veslud/Révillon; Berger et al. in this volume).

2. The production process

Work force, understood in an energetic sense, is an abstraction of the human involvement in any economic activity and at the same time the immediate physical limit all societies are faced with. The amount of labour required for a particular production therefore inevitably affects the production value of the generated objects or services (cf. M. Müller in this volume). Both vary according to the economic productivity achieved through technological development, division of labour and the volume of manufactured goods.

- According to experimental and ethnographic data, grinding/polishing is the most *labour-intensive* part of stone axe production, while for metal axes it is casting and forging (cf. Bunnefeld et al. in this volume). The sawing of rocks is a further time intensive technology, which, however, has the advantage of a much more efficient use of raw materials than flaking (cf. Meinecke et al. in this volume). The production efforts vary according to the size of the tools. In general, it can be said that larger axes are more difficult to produce and require more time and effort to polish or forge (cf. Michael et al. in this volume). Size has, therefore, a similar importance as the provenance of the raw material in the formation of the production value (cf. Brunet; Gilligny; Chondrou in this volume).

When, for whatever reason, raw materials or manufactured goods are circulated between humans, *exchange values* emerge and imply at least two different economic practices:

3. The distribution process

It includes the mechanisms used inside and between societies in order to provide its members with goods (direct access, reciprocity, redistribution, etc.). Not only the distances and means of transportation, but also social and political barriers will have an effect on the value of a given product (cf. Sørensen/Bendtsen; Klimscha; Borowski et al. in this volume).

- The extension, direction and barriers of the *circulation* of raw materials can be reconstructed through characterisation studies of the artefacts and the geoarchaeological identification of the areas of rock and metal extraction (cf. Berger et al.; Meinecke et al.; Le Carlier de Veslud/Révillon; Peres et al. in this volume).

4. Gift giving and debt

M. Mauss (1925) was the first to argue that, although gift giving – the main early form of exchanging goods – creates strong social bonds among persons and communities, it can also end in the subjugation of individuals or groups which are unable to respond to a debt caused by excessive gifts. The debt of humans to nature, of children to adults, of the living to the dead, etc., creates a tight network of obligations

3. Der Distributionsprozess

Er beinhaltet die Mechanismen, die innerhalb und zwischen Gesellschaften eingesetzt werden, um ihre Mitglieder mit Gütern zu versorgen (direkter Zugang, Gegenseitigkeit, Umverteilung usw.). Nicht nur Entfernungen und Transportmittel, sondern auch soziale und politische Hindernisse wirken sich auf den Wert eines bestimmten Produkts aus (vgl. Beiträge Sørensen/Bendtsen; Klimscha in diesem Band).

- Die Ausdehnung, Richtung und die Hindernisse des *Umlaufs* von Rohmaterialien können mithilfe der Untersuchung von Artefaktmerkmalen und der geoarchäologischen Identifizierung von Abbaugebieten von Gestein und Metall rekonstruiert werden (vgl. etwa die Beiträge Berger u. a.; Meinecke u. a.; Le Carlier de Veslud/Révillon; Peres u. a. in diesem Band).

4. Schenken und Schulden

M. Mauss (1925) erkannte als Erster, dass Schenken – die wichtigste Frühform des Warentauschs – zwar starke soziale Bindungen zwischen Personen und Gemeinschaften bewirkt, jedoch auch zur Unterwerfung von Individuen oder Gruppen führen kann, die nicht in der Lage sind, auf eine durch übermäßige Geschenke entstandene Schuld angemessen zu reagieren. Die Schuld der Menschen der Natur, der Kinder den Erwachsenen, der Lebenden den Toten gegenüber usw. erschafft ein enges Netz von Verpflichtung und Solidarität (Graeber 2012). Dennoch kann die Verpflichtung, Schulden zurückzuzahlen, nur bestehen, wenn etwas anderes die Menschen dazu zwingt, in sozialen Einheiten zu leben: Das menschliche Überleben hängt von Kooperation im Bereich der Produktion ab, woraus die Verpflichtung entsteht, die produzierten Güter zusammenzulegen, zu teilen und zu geben (Risch 2016). Ausschließlich dieser Umstand erklärt den Austausch symbolträchtiger Objekte mit nur begrenzten oder gar keinen technischen Vorteilen, die in denjenigen prähistorischen Gesellschaften so oft zu beobachten sind, für welche soziale Asymmetrien und politisch dominante Positionen nur eingeschränkt belegt sind (Risch 2018; vgl. Beitrag Sheridan in diesem Band).

- Der archäologische Kontext, bei dem Axt- und Beilklingen aus exotischen Materialien in Siedlungen, Gräbern oder Horten gefunden werden, sowie Spuren einer sukzessiven Herstellung an den Artefakten liefern Erkenntnisse über den kollektiven oder exklusiven Charakter, in dem Objekte mit hohem Produktions- und Tauschwert gehandhabt wurden. Beispiele *par excellence* hierfür sind die Jadeitit- und Eklogitbeile (vgl. Beiträge Sheridan; Rodríguez-Rellán/Fabregas Valcarce; Dietrich u. a. in diesem Band), aber möglicherweise auch große und polierte Silexbeile (vgl. Beiträge Brunet; Beran u. a. in diesem Band).

Aus Sicht des Konsums lässt sich der *Gebrauchswert* zumindest anhand der folgenden beiden Parameter definieren (Risch 2011):

5. Die materielle und technische Nützlichkeit,

die ein Produkt bietet. Dieser Wert ergibt sich aus der menschlichen Fähigkeit, die Eigenschaften oder die Qualität eines Produkts zu nutzen, um bestimmte Aufgaben zu erle-

and solidarities (Graeber 2012). Yet the obligation to repay debts can only be sustained if something else forces humans to live in social units: Human survival depends on cooperation in the realm of production, out of which emerges the obligation of pooling, sharing, and giving the produced goods (Risch 2016). This circumstance alone explains the exchange of highly symbolic objects with only limited or no technical advantages that are so often observed in those prehistoric societies for which social asymmetries and politically dominant positions are only documented to a limited extent (Risch 2018; cf. Sheridan in this volume).

- The archaeological context where axeheads of exotic materials are found in settlements, tombs, or hoards, as well as the successive manufacturing traces which can be observed on the artefacts, provide insight into the collective or exclusive character in which objects with a high production and exchange value were handled. Examples *par excellence* are the jadeitite and eclogite axes (cf. Sheridan; Rodríguez-Rellán/Fabregas Valcarce; Dietrich et al. in this volume), but possibly also large and polished flint axes (cf. Brunet; Beran et al. in this volume).

From the point of view of consumption, the *use value* can be defined at least by the following two parameters (Risch 2011):

5. The material and technical utility

a product provides. This value results from the human ability to use the properties or the quality of a product to accomplish certain tasks or to satisfy certain needs or desires. At a social rather than individual level, the use value is expressed through the relative importance a product has in a specific society. Contrary to what marginalist thinking might suggest, the most useful goods in a society are the most frequent ones rather than the most *scarce* or rare ones (water, food, dress, housing, etc.). Just as in other social sciences, archaeology generally succumbs to the marginalist perspective when assigning, on principle, a much higher explicative value to rare and elaborate objects, often made out of particular materials, than to common artefacts. This tacitly creates a perception that assumes that such objects were just as scarce in the past as they are in the modern antiques trade and are therefore an expression of »prestige.« And, in fact, this is their function, e.g., in the entrance hall of a magnate. The explanation of the *relations* necessary in order to claim scarcity and prestige is generally omitted.

- The *quality of the raw material* resulting from the material composition as well as the fabric of the rocks and metals has a direct effect on the functional properties and hence on the use value of the artefacts, as numerous articles in this volume demonstrate. Mechanical properties of the raw materials are required in order to compare these rocks in terms of their resistance to flexural or breaking strength (Delgado Raack et al. 2020; cf. Michael et al.; Skorna in this volume).
- Functional analyses are required in order to approach the utility of the axes (Masclans 2017; cf. Dietrich et al. in this volume). The observation of residues as well as traces due to use and maintenance allows archaeolo-

digen oder bestimmte Bedürfnisse oder Wünsche zu befriedigen. Auf einem eher sozialen als individuellen Niveau wird der Gebrauchswert durch die relative Bedeutung eines Produkts in einer bestimmten Gesellschaft ausgedrückt. Entgegen dem, was die marginalistische Denkweise vorschlagen mag, sind die nützlichsten Güter in einer Gesellschaft die häufigsten und nicht die knappsten oder seltensten (Wasser, Nahrung, Kleidung, Behausung usw.). Ebenso wie andere Sozialwissenschaften unterwirft sich die Archäologie meist der marginalistischen Sichtweise, wenn sie seltenen und aufwendigen, häufig aus einem besonderen Material hergestellten Objekten grundsätzlich einen viel höheren Erklärungsgehalt zuweist als gewöhnlichen Artefakten. Stillschweigend wird damit eine Wahrnehmung entworfen, die davon ausgeht, dass solche Objekte in der Vergangenheit ebenso selten waren wie im modernen Antiquitätenhandel und es sich deshalb um einen Ausdruck von »Prestige« handelt. Und tatsächlich trifft dies genau ihre Funktion, z. B. in der Eingangshalle eines Magnaten. Die *Beziehungen*, derer es bedarf, um Seltenheit und Prestige in Anspruch zu nehmen, werden meist gar nicht erläutert.

- Die *Qualität des Rohmaterials,* die sich aus der materiellen Zusammensetzung sowie aus der Beschaffenheit der Gesteine und Metalle ergibt, hat einen direkten Einfluss auf die funktionalen Eigenschaften und damit den Gebrauchswert des Artefakts, wie zahlreiche Beiträge des vorliegenden Bandes demonstrieren. Mechanische Eigenschaften des Rohmaterials sind nötig, um diese Gesteine in Bezug auf ihre Biegezug- oder Bruchfestigkeit zu vergleichen (Delgado Raack et al. 2020; vgl. Beiträge Michael u. a.; Skorna in diesem Band).
- Funktionsanalysen sind nötig zur Bestimmung der Nützlichkeit von Äxten und Beilen (Masclans 2017; vgl. Beitrag Dietrich u. a. in diesem Band). Die Betrachtung von Rückständen sowie Gebrauchs- und Instandhaltungsspuren ermöglicht es Archäologen, zwischen einem eher praktischen oder aber symbolischen Artefakt zu unterscheiden.

6. Die ästhetische und symbolische Nützlichkeit,

die ein Produkt bietet. Es handelt sich dabei um subjektive Werte, die auf Dinge projiziert werden. Sie können entweder soziale Anerkennung oder individuelle Wiedergutmachung geben; sie sind entweder durch Macht auferlegt oder beruhen auf den Konventionen einer Gesellschaft und können jederzeit verworfen oder verändert werden. Dadurch werden sie anpassungsfähig und zugleich unverzichtbar für die Organisation einer Gesellschaft auf kognitiver und kommunikativer Ebene. In materieller Hinsicht kann man sich solchen Merkmalen nur nähern, indem man den Produktionswert und den tatsächlichen Nutzen eines bestimmten Objekts vergleicht. Die Bedeutung eines sorgfältig hergestellten Produkts aus einem Material, das aus großer Entfernung herangeschafft wurde, das aber keinerlei Gebrauchsspuren aufweist, muss zum Beispiel die Sphäre der wirtschaftlichen Produktion überschritten haben. Oft werden solche Gegenstände zu *Fetischen*, die Verwirrung zwischen der tatsächlichen Machtausübung und ihrer Repräsentation stiften sollen. Analytisch bedeutet dies, dass der ästhetische oder symbolische Beitrag zum Wert nur als *a-posteriori*-Ergebnis

gists to distinguish between a more utilitarian or a more symbolically charged artefact.

6. The aesthetic and symbolic utility

a product provides. These are subjective values projected into things; they can provide either social recognition or individual redemption. Such values are either imposed through power or based on conventions inside society, and at any moment they can be abolished or transformed. This makes them in fact flexible and, at the same time, indispensable for the organisation of a society at a cognitive and communicative level. From a material perspective, such values can only be approached by comparing the production value and the actual use made out of a specific object. Thus, for example, the meaning of a carefully manufactured product of a material that has circulated over a long distance, but which shows no use-wear traces, must have exceeded the sphere of economic production. Frequently, such objects become *fetishes* intended to generate confusion between the actual exercise of power and its representation. Analytically, this implies that the aesthetic or symbolic contribution to value can only be recognised as an *a posteriori* result of the analysis of production and consumption processes in a specific historic context, but not as an explicative device in its own right. These two dimensions of use value (material/technical and aesthetic) would respect the distinction underlined by D. Graeber (2001) between objects with power to act directly on persons (and things, we would add) and objects with power to inspire actions in others.

- The *symbolic use* of the axes can be derived from the relation observed between the distance of circulation of the rock and metal types, their mechanical resistance (or lack of it), their size and colour, and their use-wear traces (cf. Sheridan; Bonora Soriano in this volume).

The heuristic importance of the notion of *social value* lies precisely in the fact that its meaning emerges from the interplay between production, distribution, and consumption (Marx 1858 [1973], 84–111), between objective material conditions and personal desires, between the power to impose certain economic constraints and the attempts to overcome them. Social value expresses the subjective as well as objective perception of the qualitative properties of all goods, and it explains the dialectical construction of value through the interplay between social forces and particular interests in history. Most of these approaches to *social value* are addressed in multiple ways in the different contributions of the present volume, which presents the results of the 16th Archaeological Conference of Central Germany.

Rocks, minerals, and the social value of axes

As the contributions in this volume confirm (Fig. 1), the study of axes should not deal with different aspects from which their social value can be derived, but approach their value holistically. The development of economic thinking over the last 2300 years provides a conceptual guide on how such an approach can be performed. However mul-

der Analyse von Produktions- und Konsumprozessen in einem bestimmten historischen Kontext erkannt werden kann und nicht als eigenständiges Erklärungsinstrument. Diese zwei Dimensionen des Gebrauchswerts (materiell/technisch und ästhetisch) würden den von D. Graeber (2001) hervorgehobenen Unterschied zwischen Gegenständen berücksichtigen, welche die Macht haben, auf Menschen (und Dinge, würden wir hinzufügen) direkt zu wirken, oder aber die Macht, andere zu Handlungen zu inspirieren.

- Der *symbolische Gebrauch* der Äxte und Beile kann aus der Beziehung abgeleitet werden, die zwischen der Entfernung zum Ursprung der Gesteins- und Metallarten, ihrer mechanischen Widerstandsfähigkeit (oder einem Mangel daran), ihrer Größe und Farbe sowie ihrer Gebrauchsspuren beobachtet werden kann (vgl. Beiträge Sheridan; Bonora Soriano in diesem Band).

Die heuristische Bedeutung des Begriffs vom *sozialen Wert* beruht auf genau der Tatsache, dass sich sein Wert aus dem Wechselspiel zwischen Produktion, Verbreitung und Konsum ergibt (Marx 1858 [1973], 84–111), zwischen objektiven materiellen Bedingungen und persönlichen Wünschen, zwischen der Macht, bestimmte wirtschaftliche Zwänge aufzuerlegen, und den Versuchen, diese zu überwinden. Der soziale Wert drückt sowohl die subjektive als auch objektive Wahrnehmung der qualitativen Eigenschaften aller Güter aus und erklärt die dialektische Konstruktion von Wert anhand des Wechselspiels zwischen gesellschaftlichen Kräften und besonderen Interessen in der Geschichte. Die meisten dieser Ansätze zum *sozialen Wert* werden in den Beiträgen dieses Bands mit den Ergebnissen des 16. Mitteldeutschen Archäologentags auf vielfältige Weise thematisiert.

Gesteine, Mineralien und der soziale Wert von Beilen und Äxten

Wie die Beiträge in diesem Band bestätigen (Abb. 1), sollte es bei der Untersuchung von Beilen und Äxten nicht um unterschiedliche Gesichtspunkte gehen, unter denen man ihren sozialen Wert begreifen kann, sondern darum, sich ihrem Wert ganzheitlich zu nähern. Die Entwicklung des ökonomischen Denkens in den letzten 2300 Jahren liefert einen konzeptionellen Leitfaden, wie eine solche Annäherung aussehen kann. Egal wie vielschichtig und komplex der soziale Wert von Dingen sein mag, sowohl Aristoteles als auch die erste moderne Schule der Wirtschaftsanalyse, bekannt als Physiokratie, vertraten aus gutem Grund die Ansicht, dass aller Wohlstand hauptsächlich aus der Ausbeutung des Landes und anderer Ressourcen herrührt. Man ging davon aus, dass die Menge der natürlichen Ressourcen, über die eine Gesellschaft verfügen konnte, für die Wirtschaft viel relevanter war als die Produktion, der Handel oder jede andere Art von Tätigkeit. Welche Werte die Äxte und Beile durch Zyklen von Herstellung, Umlauf, Lagerung, Gebrauch, Schärfen oder Nachpolieren auch erhielten, die erste wirtschaftliche Handlung musste in der Beschaffung beträchtlicher Mengen Rohmaterial aus natürlichen Aufschlüssen bestehen. Die Entfernungen, in denen Gesteine und Mineralien gefunden wurden, ihre mechanischen Eigenschaften, Farbe und Glanz, die Schwierigkeiten, sie zu erreichen, die Landschaften, in denen sie abgelagert wurden, etc., stehen am Beginn des Wertschöpfungsprozesses. Alle anderen Formen von Wert, die den Äxten beigemessen wurden, werden entweder die Erinnerung oder das Geheimnis dieser ersten Begegnung mit der Natur verkörpern.

An introduction to a conference and publication on the social value of axes after more than 100 years of geoarchaeological and archaeometrical studies would seem to be the right place and moment to compare and to reflect on the outcrops and deposits, which are known to have been exploited from the Neolithic to the Bronze Age, on their location and distribution, as well as on their socio-economic and symbolic implications. The maps presented in Fig. 2 to 4 are a first attempt at a European spatial representation of the main sites where rocks, ores, and minerals where obtained, with a higher or lower degree of certainty according to the present stage of research. The generated maps – however provisional they may be – also mirror the research history of geoarchaeology and archaeometry. In the case of the rocks used to manufacture axeheads, the long tradition of stone axes studies on the British Isles, but also other parts of western Europe, is manifest (cf. Fig. 2). Much less is known about the exploitation of rocks in eastern Europe, where research instead has focused on the mining of copper ores during the Chalcolithic (or Copper Age) or in the Aeneolithic according to regional terminology (cf. Fig. 3). Yet here it needs to be noted – and this might explain social differences between (south-)eastern and western Europe in later prehistory – that the used periodisation veils the contemporaneity of both realities between c. 5000 and 2200 BC, when the societies in the West focused on rocks, while in the East they extracted metals.

The abundance and widespread distribution of petrographically confirmed sites of rock exploitation also highlights areas with a longer research tradition, such as the British Isles, France, or north-eastern Iberia (cf. Fig. 2). From a geological perspective, rocks adequate for axe production can be found in the two main orogenic formations crossing different parts of Europe, the Alpine and the Variscan, as well as in volcanic outcrops. Sedimentary rocks, mostly flint, provide a further source of materials suitable to be transformed through flaking and – in this case – exceptionally time-consuming polishing into axeheads. Hence, a large variety of igneous and metamorphic as well

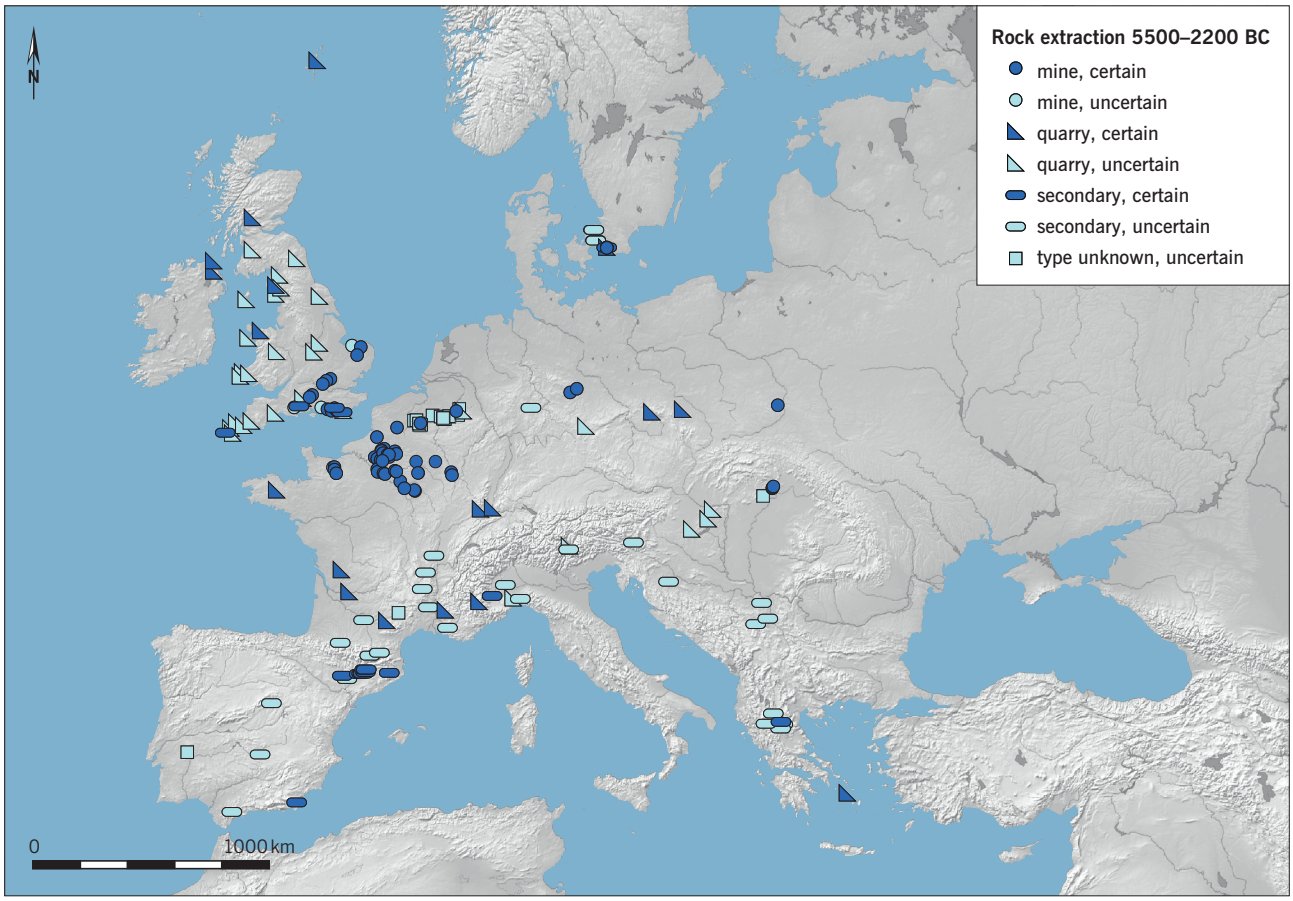

Abb. 2 Gesicherte oder – aufgrund geologischer Gegebenheiten und archäologischer Produktionsnachweise – angenommene Abbaugebiete von Gesteinen zur Herstellung von Beilen und Äxten zwischen ca. 5500 und 2200 v. Chr. In den meisten Fällen ist es möglich, zwischen Förderung aus Schächten, Tagebau und sekundären Lagerstätten zu unterscheiden. Diese Karte will keinen Anspruch auf Vollständigkeit erheben, sondern nur die wichtigsten bisher nachgewiesenen oder vermuteten Abbaugebiete zeigen. Die Karte spiegelt eindeutig auch die größere Foschungstradition in Westeuropa in Bezug auf die petrografische und geologische Erforschung von Steinbeilen wider.

Fig. 2 *Confirmed or – based on geological conditions and archaeological proof of production – assumed primary and secondary extraction areas of rocks for the manufacture of axes between c. 5500 and 2200 BC. In most cases, underground mining, quarrying, and secondary deposits can easily be distinguished. This map makes no claim to be exhaustive; it only shows the most important mining areas proved or assumed up to now and clearly reflects the more pronounced research tradition in Western Europe regarding the petrographic and geological investigation of stone axeheads.*

keiten beim Erreichen der Lagerstätten, die abschreckenden Erfahrungen in den – oft unbewohnten und abgelegenen – Landschaften, in denen sie vorkamen, und vieles andere stehen am Anfang des Wertbildungsprozesses. Alle anderen Formen von Wert, die mit diesen Äxten und Beilen verbunden sind, schließen entweder das Geheimnis dieser ersten Begegnung mit der Natur oder die Erinnerung daran ein.

Nach mehr als 100 Jahren geoarchäologischer und archäometrischer Untersuchungen scheint die Einführung zu einer Tagung und einer Veröffentlichung über den sozialen Wert von Äxten und Beilen der richtige Ort und Zeitpunkt für einen Vergleich und eine Reflektion über die seit dem Neolithikum bis in die Bronzezeit abgebauten Aufschlüsse und Vorkommen zu sein, über ihre Lage und Verteilung sowie über ihre sozioökonomische und symbolische Bedeutung zu sprechen. Die Karten Abb. 2 bis 4 sind ein erster Versuch, europaweit die wichtigsten Abbauorte von Felsgestein, Erzen und Mineralien räumlich darzustellen; dies geschieht mit mehr oder weniger großer Gewissheit, je nach dem aktuellen Stand der Forschung. Die erzeugten Karten – wie vorläufig sie auch sein mögen – spiegeln ebenfalls die

as certain sedimentary rocks were available in almost all regions and could provide Neolithic communities with the necessary raw materials for axe manufacture. This abundance of resources probably had a direct impact on the circulation of raw materials and goods and the resulting areas of interaction between communities. Several studies carried out independently in different regions of western Europe seem to agree that Neolithic societies were faced with considerable difficulties or were not interested in establishing regular and large scale procurement strategies beyond c. 200 km distances. In the case of Sardinian and Liparian obsidian (Pollmann 1993; Costa 2007), western Mediterranean axes (Risch 2011), the meta-dolerite axes from the Bretagne (Le Roux 1999), Welsh »bluestone« axes (Darvill 1989) or Benelux »Buren« flint axes (Bakker 2006), among others, it seems that distances beyond c. 200 km sources were not overcome to ensure a solid and regular supply. Beyond this limit, non-local materials usually played a marginal role in comparison to local ones, and basically represented *exotica* that were circulated for their exchange and symbolic value rather than their mechanic or functional properties *(use value)*. The only

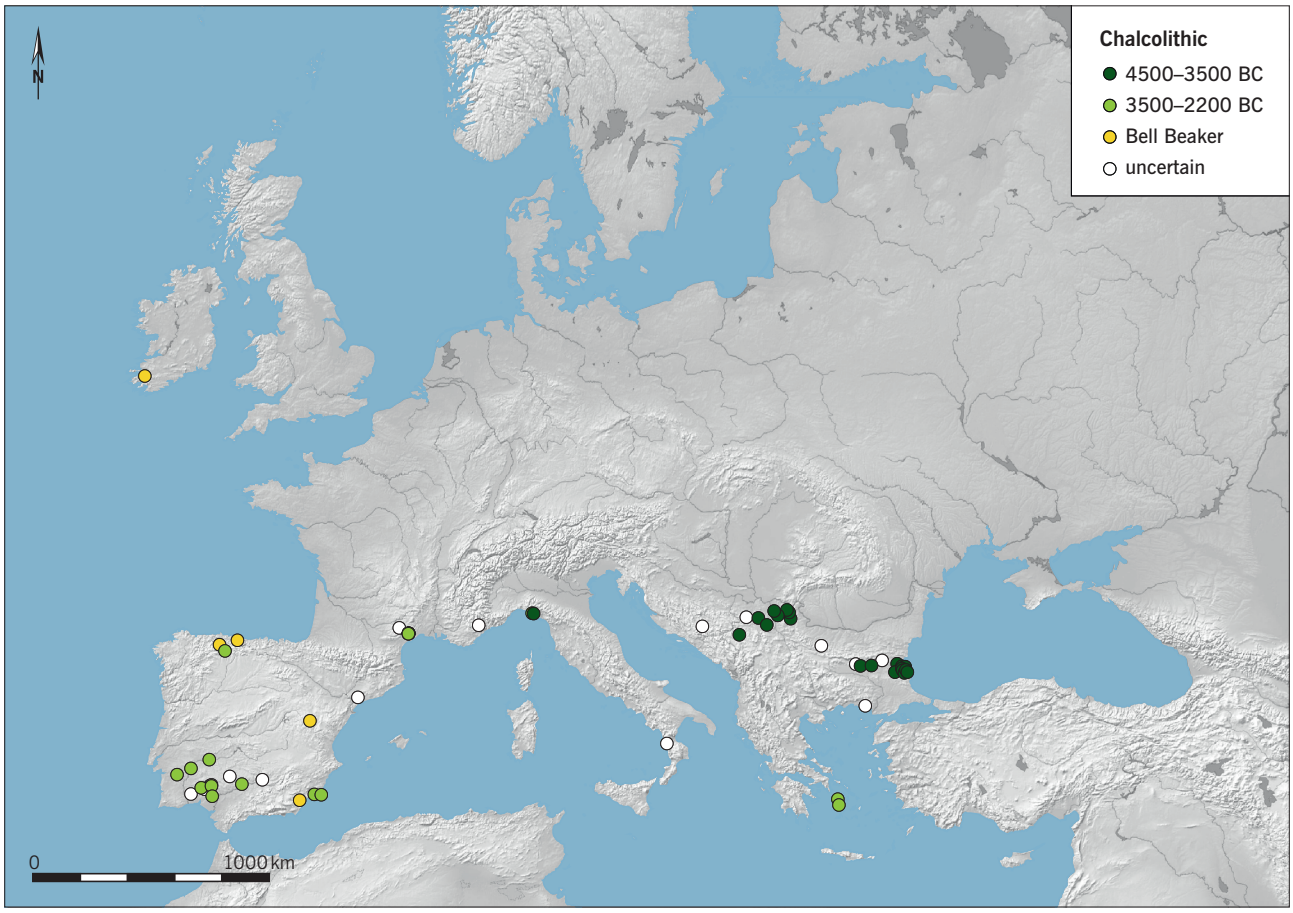

Abb. 3 Gesicherter und vermuteter Abbau von Kupfererzen zwischen ca. 4500 und 2200 v. Chr. Diese Karte will keinen Anstruch auf Vollständigkeit erheben, sondern nur die wichtigsten bisher nachgewiesenen oder angenommenen Bergwerke zeigen.

Fig. 3 *Confirmed and assumed mining areas of copper ores between c. 4500 and 2200 BC. This map makes no claim to be exhaustive; it only shows the most important mining areas proved or assumed up to now.*

Forschungsgeschichte der Geoarchäologie und der Archäometrie wider. Im Falle von Gesteinen für Axt- und Beilklingen zeigt sich die lange Forschungstradition der Britischen Inseln und anderer Teile Westeuropas (vgl. Abb. 2). Weit weniger ist über den Felsgesteinabbau in Osteuropa bekannt, wo sich die Forschung stattdessen auf den Abbau von Kupfererzen im Chalkolithikum (oder Kupferzeit) bzw. im Äneolithikum nach der regionalen Terminologie konzentriert hat (vgl. Abb. 3). Dennoch muss hier angemerkt werden, dass die angewandte Periodisierung die Gleichzeitigkeit beider Realitäten zwischen etwa 5000 und 2200 v. Chr. verschleiert, als die Gesellschaften des Westens sich auf Gestein konzentrierten, der Osten hingegen Metalle gewann.

Die große Anzahl und weite Verbreitung von petrografisch bestätigten Fundorten von Gesteinsabbau weisen auch auf Gebiete mit einer längeren Forschungstradition hin, wie die Britischen Inseln, Frankreich oder die nordöstliche Iberische Halbinsel (vgl. Abb. 2). In geologischer Hinsicht finden sich Gesteine, die für die Axt- und Beilherstellung geeignet sind, in vulkanischen Aufschlüssen sowie in alpinen und variszischen, deren Gebirgsformationen verschiedene Teile Europas durchqueren. Sedimentgestein, meist Feuerstein, stellt eine weitere Quelle brauchbaren Materials dar, das durch Abschlagen und – im Fall von Feuerstein – besonders zeitintensives Schleifen sowie Polieren in Beilklingen verwandelt wird. Eine

exceptions to this pattern were the circulation of greenschist from the Jizera (cf. Šída/Burgert in this volume), and probably from the Vogtland, over most of central Europe – i.e., distances of up to 650 km – during the Early Neolithic (c. 5500–4500 BC; Moník et al. 2021; cf. Meinecke et al. in this volume), and the circulation of jadeitite and eclogite axes of the Mont Viso and other outcrops of the western Alps between c. 4800 and 3700 BC (Pétrequin et al. 2012; Pétrequin et al. 2017).

However, the exceptional distances and volumes in which these rocks circulated obscures the fundamental differences existing between both networks and the societies engaged in them. The extensive supply of greenstone axes probably led to a decline in the extraction of other raw materials and outcrops in large parts of Central Europe, which may be reflected in the close and far-reaching social relations of the first farming communities – especially for the Linear Pottery Culture, the Stroke-ornamented ware Culture and the Rössen Culture (Moník et al. 2021). The decisive factor that led to the circulation of a much smaller number of Alpine greenstone axes beyond 400–500 km and even up to a distance of 1600 km seems to have been the emerging idea of an exchange value resulting from the possibility of intensive remodelling of these highly abrasive rocks. This seems to have been an emerging notion

Vielzahl magmatischen und metamorphen Gesteins sowie bestimmte Sedimentgesteine waren in fast allen Regionen verfügbar und lieferten neolithischen Gemeinschaften das benötigte Rohmaterial zur Axt- und Beilherstellung. Dieser Ressourcenreichtum hatte wahrscheinlich direkte Auswirkungen auf den Umlauf von Rohmaterialien und Waren sowie auf die sich daraus ergebenden Interaktionsbereiche zwischen Gemeinschaften. Mehrere unabhängig voneinander durchgeführte Untersuchungen in unterschiedlichen Regionen Westeuropas scheinen darin übereinzustimmen, dass neolithische Gesellschaften sich mit großen Schwierigkeiten konfrontiert sahen oder aber nicht daran interessiert waren, regelmäßige und groß angelegte Beschaffungsstrategien über mehr als ca. 200 km Entfernung zu etablieren. Solche Distanzen wurden im Fall von Obsidian aus Sardinien und von den Liparischen Inseln (Pollmann 1993; Costa 2007) und unter anderem bei westmediterranen Beilen (Risch 2011), den Metadolerit-Beilen aus der Bretagne (Le Roux 1999), walisischen »Blaustein«-Beilen (Darvill 1989) oder den sogenannten Burenbeilen aus Feuerstein in den Beneluxländern (Bakker 2006) offenbar nicht überwunden, um eine solide und regelmäßige Versorgung zu gewährleisten. Im Vergleich zu lokalen spielten ortsfremde Materialien über diese Entfernung hinaus meist eine untergeordnete Rolle und stellten Raritäten dar, die um ihres Tausch- und Symbolwertes willen kursierten und nicht aufgrund ihrer mechanischen oder funktionellen Eigenschaften (Gebrauchswert). Die einzigen Ausnahmen davon waren der Umlauf von Grünschiefer von der Jizera (vgl. Beitrag Šída/Burgert in diesem Band) und vermutlich auch aus dem Vogtland in weiten Teilen Europas, das heißt von bis zu 650 km, während des Frühneolithikums (ca. 5500–4500 v. Chr.; Moník et al. 2021; vgl. Beitrag Meinecke u. a. in diesem Band) und der Umlauf von Jadeitit/Omphacitit- und Eklogit-Beilen vom Monte Viso und von anderen Aufschlüssen der westlichen Alpen zwischen etwa 4800 und 3700 v. Chr. (Pétrequin et al. 2012; Pétrequin et al. 2017).

Die außergewöhnlichen Entfernungen und Mengen, in denen diese Gesteine zirkulierten, verschleiern jedoch die grundlegenden Unterschiede zwischen beiden Netzwerken und den an ihnen mitwirkenden Gesellschaften. Die umfangreiche Versorgung mit Grünschieferbeilen führte wahrscheinlich zu einem Rückgang beim Abbau anderer Rohmaterialien und Aufschlüsse in großen Teilen Mitteleuropas, was sich möglicherweise in den engen und weitreichenden sozialen Beziehungen der ersten Ackerbaugemeinschaften – insbesondere für die Linienbandkeramik-, Stichbandkeramik- und Rössener Kultur – zeigt (Moník et al. 2021). Der entscheidende Faktor, der zum Umlauf einer viel geringeren Zahl alpiner Grünsteinäxte über 400–500 km hinaus und sogar bis zu einer Entfernung von 1600 km führte, scheint die aufkommende Idee eines Tauschwerts gewesen zu sein, die sich aus der Möglichkeit einer intensiven Umgestaltung dieser höchst abriebfesten Gesteine ergab (Delgado Raack et al. 2020). Die Ergebnisse mechanischer Prüfungen haben ergeben, dass der Grünschiefer, der im Isergebirge ausgiebig gefördert wurde, durch Schleifen schwieriger zu formen ist, jedoch nicht unbedingt eine bessere Biegefestigkeit und damit höhere Bruchfestigkeit als andere europäische Gesteine aufweist (Moník et al. 2021). Die Gesteine aus den westlichen Alpen brachten höhere Produktionskosten mit sich, jedoch auch eine beträchtliche

of *exchange value* resulting from the intensive reshaping and polishing of these highly friction-resistant rocks along their circulation routes (Delgado Raack et al. 2020). The results provided by mechanical tests have shown that the greenschist, which was intensively quarried in the Jizera Mountains, is harder to shape through grinding but does not necessarily offer a better flexural strength and, hence, a higher resistance to breakage than other European rocks (Moník et al. 2021). The rocks coming from the West Alpine area implied considerably higher manufacture costs but also offered exceptionally hard and strong mechanical properties. At distances beyond 400–500 km from the sources, what distinguishes the complex circulation of Alpine jadeitite and eclogite from all the other rocks mechanically tested so far is not so much their exceptional suitability for tree felling and wood working tools, but their potential to be modified without compromising their integrity, thanks to their exceptional resistance to friction (Delgado Raack et al. 2020).

Even with the beginning of metal utilisation, axes did not lose their various dimensions of meaning (cf. Dietrich; Dolfini; Müller et al.; Nørgaard in this volume). Beginning with the Copper Age, they were, for example, by far the most common metal artefacts in hoards (cf. Dietrich; Hansen in this volume). Today, hoards are usually associated with social practices anchored in the religious sphere, often including the intentional fragmentation of objects (cf. Skorna in this volume). Their role as goods for deposition is based on both the exchange value of the axes (cf. Mehlheim in this volume) and the value of the raw material (cf. Nørgaard in this volume). In comparison with stone, metal has the advantage of being recyclable. Irreparably damaged objects can be melted down and their raw material reused. As copper, much like rock deposits, can only be exploited in certain regions, the directions of exchange shifted, but the general set-up remained constant. Moreover, stone implements remained in use for a long time in parallel with metal (cf. Dobeš in this volume).

The introduction of tin bronze resulted in even more complexity, as the tin necessary for producing this alloy can only be found in very few places in Europe. The prestige value of Bronze Age axes was therefore sometimes high; and this was justified not only by the effort of raw material procurement, which can be determined using lead isotope analyses (cf. Le Carlier de Veslud/Révillon; Berger et al. in this volume), but also by the amount of work involved (cf. Bunnefeld et al.; Dalidowski et al.; Michael et al.; Peres et al. in this volume), which could even include coating with silver to achieve certain colour effects (cf. Schimerová et al. in this volume). The colourfulness of axes and other weapons was, for instance, one of the status markers in the Central German Únětice Culture (Meller/Bunnefeld 2020). The prestige value of axes is expressed not only by their deposition in some regions of Europe but also through their use in burial contexts (cf. Bonora Soriano in this volume).

The early exchange systems of copper are currently not fully understood, but patterns are starting to show and were further advanced as part of this conference. The

Härte und damit außergewöhnliche mechanische Eigenschaften. Trotz Entfernungen von über 400–500 km von ihrem Ursprung und dem komplexen Umlauf von alpinem Jadeitit und Eklogit unterscheiden sich diese von allen anderen bisher mechanisch geprüften Gesteinsarten nicht so sehr durch ihre besonders gute Eignung für Baumfäll- und Holzbearbeitungswerkzeuge, sondern dass sie sich ohne Beeinträchtigung ihrer materiellen Integrität verändern lassen – dank ihrer außergewöhnlichen Widerstandsfähigkeit gegen Abrieb (Delgado Raack et al. 2020).

Auch mit Beginn der Metallnutzung verlieren Äxte und Beile ihre verschiedenen Bedeutungsdimensionen nicht (vgl. Beiträge Dietrich; Dolfini; J. Müller u. a.; Nørgaard in diesem Band). Dies zeigt sich beispielsweise dadurch, dass Äxte und Beile seit der Kupferzeit die bei Weitem häufigsten Metallartefakte in Hortfunden sind (vgl. Beiträge Dietrich; Hansen in diesem Band), die heute allgemein mit im religiösen Bereich verankerten sozialen Praktiken verbunden werden und häufig die intentionelle Fragmentierung der Gegenstände einschließt (vgl. Beitrag Skorna in diesem Band). Die Rolle als Deponierungsgut basiert sowohl auf dem Tauschwert der Beile (vgl. Beitrag Mehlheim in diesem Band) als auch dem Wert des Rohmaterials (vgl. Beitrag Nørgaard in diesem Band). Gegenüber Stein hat Metall den Vorteil der Möglichkeit des Recyclings. Irreparabel beschädigte Gegenstände können eingeschmolzen und das Rohmaterial erneut verwendet werden. Da Kupfer wie auch die Gesteinsvorkommen nur in bestimmten Regionen abgebaut werden kann, verlagern sich die Richtungen des Austauschs zwar, doch bleiben die Rahmenbedingungen konstant. Zudem bleiben Steingeräte noch lange parallel zum Metall in Nutzung (vgl. Beitrag Dobeš in diesem Band).

Das Aufkommen von Zinnbronze führte zu einer Erhöhung der Komplexität, denn das Legierungsmetall Zinn ist nur an ausgesprochen wenigen Orten in Europa zu finden. Der Prestigewert bronzezeitlicher Äxte ist daher mitunter hoch, begründet nicht nur im Aufwand der Rohmaterialbeschaffung, der sich etwa über Bleiisotopenuntersuchungen bestimmen lässt (vgl. Beiträge Le Carlier de Veslud/Révillon; Berger u. a. in diesem Band), sondern auch im Arbeitsaufwand (vgl. Beiträge Bunnefeld u. a.; Dalidowski u. a.; Michael u. a.; Peres u. a. in diesem Band), der auch den Überzug mit Silber beinhalten konnte, um bestimmte Farbwirkungen zu erzielen (vgl. Beitrag Schimerová u. a. in diesem Band). Die Farbigkeit von Beilen und anderen Waffen ist einer der Marker sozialen Status' etwa in der mitteldeutschen Aunjetitzer Kultur (Meller/Bunnefeld 2020). Zum Ausdruck kommt der Prestigewert der Beile neben der Deponierung in einigen Regionen Europas auch durch die Nutzung im Grabzusammenhang (vgl. Beitrag Bonora Soriano in diesem Band).

Die frühen Austauschsysteme für Kupfer werden momentan noch nicht komplett verstanden, doch zeichnen sich erste Muster ab, die im Rahmen der Tagung weiter herausgearbeitet werden konnten. Die derzeit bekannten frühesten Nachweise bergmännischen Abbaus von Kupfererzen liegen in Südosteuropa[3] (vgl. Abb. 3). Sie werden ergänzt

earliest known evidence of copper ore mining is found in south-eastern Europe[3] (cf. Fig. 3) and is complemented by the earliest proof of pyrotechnological copper extraction from ores. Although there is evidence that copper metal was used in the Middle East as early as the pre-pottery Neolithic and thus significantly earlier (Muhly 1989; Pernicka 2020), this copper was exclusively native (naturally occurring as metal), and pyrotechnology was only used in order to make the metal easier to process. Copper tends to crack on deformation, because it becomes hard and brittle. For larger shaping operations, repeated heating is therefore necessary to restore the softness and ductility of the metal. Various notions existed on the further technological development, which relates to the chemical transformation of copper minerals to copper metal. One suggestion was that tempering might occasionally have led to melting the metal. This hypothesis was supposedly proven by the fist-sized macehead from Can Hasan, vil. Karaman (Turkey), which had a hole of about 1 cm width and dated to c. 6000 BC (French 1962). It seemed that such a shape could only have been achieved by casting, which requires molten copper. Due to its high purity, the material was thought to be native copper, leading to the assumption that, in copper metallurgy, casting occurred before smelting. But it was later discovered that this object had been shaped not by casting but by hammering of a large lump of native copper (Yalçin 1998).

Since the processing of native copper is not associated with smelting, this first development step is not yet the actual beginning of extractive metallurgy, for which only smelting slags are unambiguous proof. In this context, the slag finds from Çatal Höyük, vil. Konya (Turkey; layer VI, c. 6500 BC), led to a controversial discussion: H. Neuninger et al. (1964) assumed that the slags »probably« derived from copper smelting. J. D. Muhly (1989) and R. F. Tylecote (1976), however, believed the material from Çatal Höyük to represent refining slags (crucible slags) rather than smelting slags. They also pointed out that the material may be interpreted as heated ore residue from jewellery production. We now know for certain that they are copper minerals heated during the burning of a house, offering no proof of metallurgical operations (Radivojević et al. 2017).

The earliest evidence for copper smelting in the form of smelting slags is currently also from south-eastern Europe (Radivojević et al. 2010; Krauss et al. 2020) and contemporaneous with the earliest heavy copper implements (mostly axes) found there. For this reason, Fig. 3 also includes mines whose exploitation could only be verified indirectly by assigning well-dated copper objects to individual geological deposits, using geochemical methods (e.g., Pernicka et al. 1997). In comparison with Fig. 2, it is obvious that the extraction of stone material for axes in south-eastern Europe played a minor role. P. Schauer et al. (2021) made similar observations regarding stone versus copper as material for axes in various periods, but only for central and western Europe. In the 4th millennium BC, copper mining spread to the western Mediterranean (cf. Fig. 3), where

3 Jovanović 1971; Chernykh 1978; Radivojević u. a. 2010; Krauss u. a. 2020.

durch die ebenfalls frühesten Nachweise der pyrotechnologischen Kupfergewinnung aus Erzen. In Vorderasien ist zwar die Verwendung von Kupfermetall bereits im akeramischen Neolithikum und damit deutlich früher nachgewiesen (Muhly 1989; Pernicka 2020), aber es wurde ausschließlich gediegenes (natürlich als Metall vorkommendes) Kupfer verwendet. Es kam zwar auch Pyrotechnologie zum Einsatz, aber nur, um das Metall besser verarbeiten zu können. Da Kupfer bei der Verformung hart und spröde wird, neigt es zu Rissen. Deshalb muss es bei größeren Umformungen immer wieder getempert (erhitzt) werden, wobei es wieder weich und duktil wird. Über die weitere technologische Entwicklung bis zur chemischen Umwandlung von Kupfermineralien zu Kupfermetall gab es verschiedene Vorstellungen. Einerseits wurde vorgeschlagen, dass das Tempern gelegentlich zum Schmelzen geführt haben könnte. Als Beleg für die Hypothese wurde der faustgroße Keulenkopf von Can Hasan, vil. Karaman (Türkei), mit einem Loch von etwa 1 cm angeführt, der auf etwa 6000 v. Chr. datiert wird (French 1962). Solch eine Form erschien nur durch Guss und damit geschmolzenem Kupfer herstellbar. Da das Metall wegen seiner hohen Reinheit für gediegenes Kupfer gehalten wurde, führte dieser Befund zu der Annahme, dass in der Kupfermetallurgie das Gießen vor dem Verhütten käme. Später stellte sich heraus, dass das Objekt nicht durch Guss, sondern durch Hämmern aus einem großen Klumpen gediegenem Kupfer geformt wurde (Yalçin 1998).

Da die Verarbeitung von gediegenem Kupfer nicht mit schmelzmetallurgischen Vorgängen verbunden ist, zählt dieser erste Entwicklungsschritt noch nicht zum eigentlichen Beginn der extraktiven Metallurgie. Sie lässt sich erst durch das Auftreten von Verhüttungsschlacken eindeutig nachweisen. In diesem Zusammenhang führten die Schlackenfunde von Çatal Höyük, vil. Konya (Türkei; Schicht VI, ca. 6500 v. Chr.), zu einer kontroversen Diskussion: H. Neuninger u. a. (1964) gingen davon aus, dass es sich dabei um Schlacken handelt, die »wahrscheinlich« aus der Kupferverhüttung stammen. Andererseits gingen J. D. Muhly (1989) und R. F. Tylecote (1976) davon aus, dass es sich bei dem Material aus Çatal Höyük um Raffinationsschlacken (Tiegelschlacken) und nicht um Verhüttungsschlacken handelt. Sie wiesen außerdem darauf hin, dass das Material auch als erhitzte Erzreste der Schmuckherstellung gedeutet werden könnte. Mittlerweile ist diese Frage geklärt: Es handelt sich definitiv um bei einem Hausbrand erhitzte Kupferminerale, die keinen Beleg für metallurgische Operationen liefern (Radivojević u. a. 2017).

Die derzeit frühesten Nachweise für Kupferverhüttung in Form von Verhüttungsschlacken sind ebenfalls in Südosteuropa zu finden (Radivojević u. a. 2010; Krauss u. a. 2020) und fallen zeitlich mit den frühesten Kupferschwergeräten (mehrheitlich Äxte) in Südosteuropa zusammen. Insofern sind in Abb. 3 auch Bergwerke eingetragen, deren Ausbeutung nur indirekt durch die Zuweisung von Kupferobjekten zu einzelnen Lagerstätten mit geochemischen Methoden gelang (z. B. Pernicka u. a. 1997). Im Vergleich zu Abb. 2 fällt auf, dass die Gewinnung von Steinmaterial für Äxte in Südosteuropa eine geringe Rolle gespielt hat. Ähnliche Beobachtungen zur Konkurrenz von Stein und Kupfer als Material für Äxte in verschiedenen Perioden wurden von P. Schauer

stone extraction also seems to have hardly played a role for axe production.

This competition between materials is particularly evident in the Alps. While silices and rock crystal were prospected and mined from the Mesolithic to the earliest Bronze Age (Bachnetzer et al. 2019), the evidence for this disappeared completely with the advent of copper mining (cf. Fig. 4). It is interesting to note in this context that after the heyday of copper production in the 5th and 4th millennium BC in south-eastern Europe, this apparently did not continue in later periods. Only in Jarmovac, Zlatibor district, in Serbia, there are signs of a second production period in the 3rd millennium BC (Thomas et al. 2024). Even in the Late Bronze Age, mainly copper from other regions seems to have been used for axes (Gavranovic et al. 2022).

No matter how incomplete and research-related the maps in Fig. 2 to 4 may be, the comparison of stone and copper mining between c. 5500 and 1000 BC clearly shows the contrast between a dense exploitation of a large variety of magmatic, metamorphic, and sedimentary rocks and an increasing concentration of copper extraction in only a few regions. The confirmed mining regions of the 2nd millennium BC seem to be much lower by numbers but of far higher significance. This concentration of raw material production must have had a crucial influence on the production value and on all other kinds of value the axes had. Their extraction and production processes became more standardised over time, as did their mechanical properties, but also their distribution and exchange networks necessarily must have been extended distinctly in order to ensure access to the artefacts that were gaining in economic and military importance. Only with the emergence of iron smelting – iron being a widespread and, one might say, ›democratic‹ metal in contrast to copper and above all bronze – was it possible to overcome this concentration of resources and thus power. This may be illustrated by the comparison with the Later Prehistory of sub-Saharan Africa, where societies managed to directly shift from a nomadic lifestyle into the Iron Age without going through a Copper and Bronze Age of about 2000 to 3000 years, like in Europe and the Near East. This shows best how decisive this period was for developing notions of value and, accordingly, the value distribution in Eurasia, which only our economic theories and society might consider to be appropriate.

Outlook

Earlier conferences on axes regularly focussed on either stone or metal implements. The Archaeological Conference of Central Germany (Fig. 5) first brought both fields of research together, and this led to fruitful exchanges and completely new perspectives on one's own research material, as was confirmed by participants during the final discussion and in many informal conversations. As it turns out, several aspects of the social handling of axes can be diachronically observed regardless of their material, albeit with nuances and region-specific expressions. The new perspective thus taken promises numerous new insights for future research.

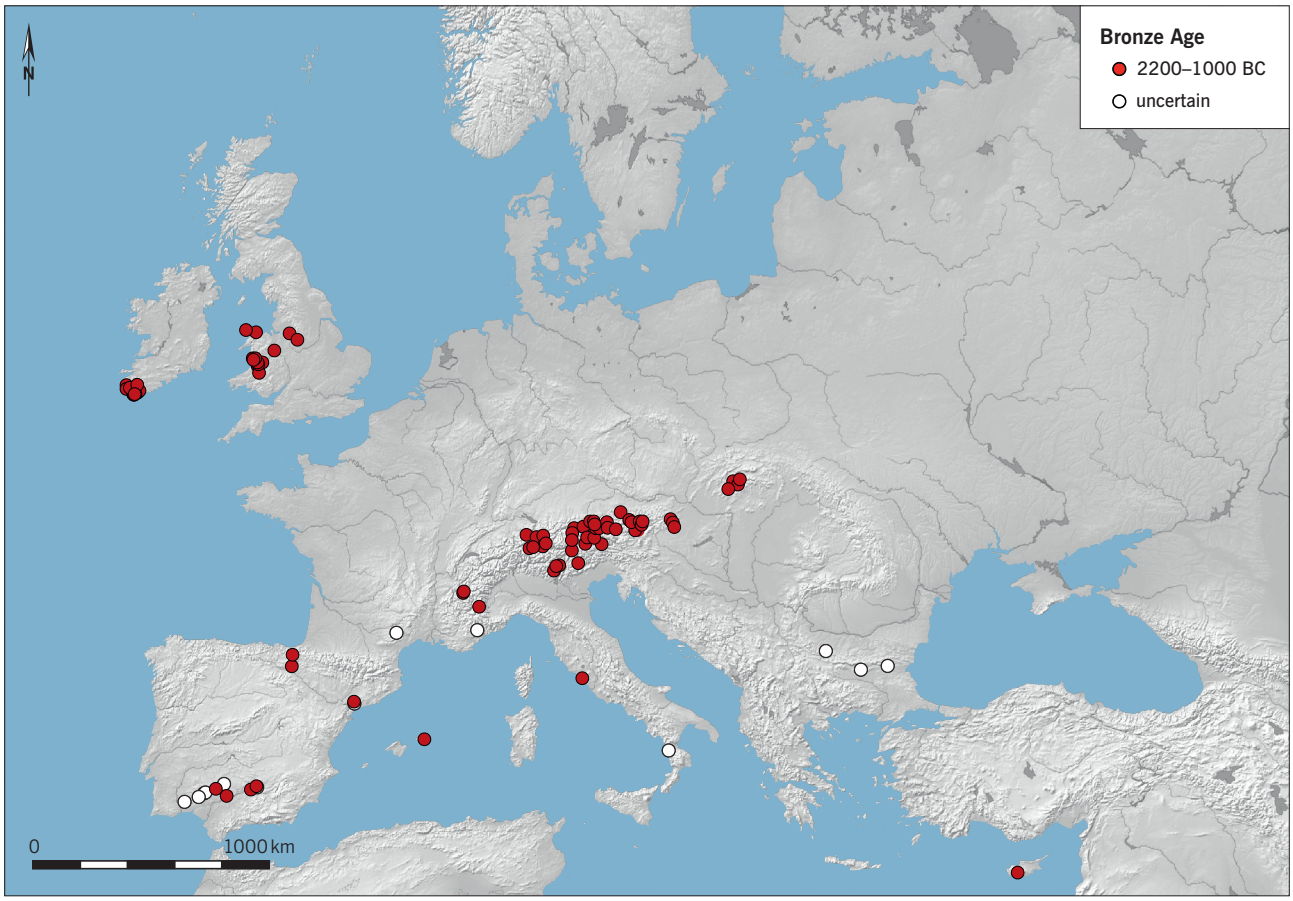

Abb. 4 Gesicherter und vermuteter Abbau von Kupfererzen zwischen ca. 2200 und 1000 v. Chr. Diese Karte will keinen Anspruch auf Vollständigkeit erheben, sondern nur die wichtigsten bisher nachgewiesenen oder angenommen Bergwerke zeigen.

Fig. 4 *Confirmed and assumed mining areas of copper ores between c. 2200 and 1000 BC. This map makes no claim to be exhaustive; it only shows the most important mining areas proved or assumed up to now.*

u. a. (2021) gemacht, allerdings nur für Mittel- und Westeuropa. Im 4. Jt. v. Chr. breitete sich die bergmännische Kupfergewinnung in den westlichen Mittelmeerraum aus (vgl. Abb. 2) und auch dort scheint die Steingewinnug für die Herstellung von Äxten kaum eine Rolle gespielt zu haben.

Diese Konkurrenz der Materialien wird besonders deutlich in den Alpen. Während Silices und Bergkristall vom Mesolithikum bis zur frühesten Bronzezeit aufgesucht und abgebaut wurden (Bachnetzer u. a. 2019), verschwinden die Belege dafür mit dem Aufkommen des Kupferbergbaus völlig (vgl. Abb. 4). Interessant ist in diesem Zusammenhang, dass nach der Blüte der Kupferproduktion im 5. und 4. Jt. v. Chr. in Südosteuropa diese in späteren Perioden offenbar keine Fortsetzung gefunden hat. Nur in Jarmovac, Okr. Zlatibor, in Serbien gibt es Anzeichen für eine zweite Produktionsperiode im 3. Jt. v. Chr. (Thomas u. a. 2024). Selbst in der späten Bronzezeit scheint Kupfer vorwiegend aus anderen Regionen für Äxte verwendet worden zu sein (Gavranovic u. a. 2022).

Was der Vergleich von Stein- und Kupferabbau zwischen ca. 5500 und 1000 v. Chr – wie unvollständig und forschungsbedingt die Karten Abb. 2 bis 4 auch sein mögen – deutlich zeigt, ist der Kontrast zwischen einer dichten Ausbeutung von einer großen Vielfalt an magmatischen, metamorphen und sedimentären Gesteinen und einer zunehmen-

Acknowledgements

We would like to thank Alison Sheridan, Nico Escanilla, Michele Cupitó, and Andrea Dolfini for swiftly and precisely answering our questions regarding maps Fig. 2 to 4. Anna Swieder deserves special mention for transferring certain and uncertain mining areas of rocks, silex, and ores into a map, using various kinds of information.

We would like to thank Claudia Gärtner and the numerous helpers for the excellent organisation of the conference as well as the Martin-Luther-University Halle-Wittenberg and the Verein zur Förderung des Landesmuseums für Vorgeschichte Halle (Saale) e. V. for their support.

The editors would particularly like to thank Manuela Schwarz, Anne Gottstein, Birte Janzen, Florian Michel, Rocco Steputat, and Aniela Schuchardt, who, as usual, realised this volume within a very short time frame.

Abb. 5 Teilnehmerinnen und Teilnehmer des 16. Mitteldeutschen Archäologentages in Halle (Saale). Von links nach rechts:

Fig. 5 *Participants at the 16th Archaeological Conference of Central Germany in Halle (Saale). From left to right:*

Lene Melheim, Petr Šída, Lasse Vilien Sørensen, Carlos Rodríguez-Rellán, Heide Wrobel Nørgaard, Oliver Dietrich, Danai Chondrou, Svend Hansen, Kristian Kristiansen, Barabara Horejs, Daniel Berger, Laura Dietrich, François Giligny, Bernadeta Kufel-Diakowska, Michał Borowski, Harald Meller, Thorsten Halle, Marcello Peres, Christian-Heinrich Wunderlich, Andrea Dolfini, Roberto Risch, Bárbara Bonora Soriano, Jan-Heinrich Bunnefeld, Ernst Pernicka, Alison Sheridan, Florian Klimascha, Michael Müller, Cécile Le Carlier de Veslud, Miroslav Dobeš, Danny Rosenberg, Eva Schimerová, Simone Meinecke, Johannes Müller (Nicht auf dem Bild/not in the picture: Claudia Becker, Michael Brandl, Jan Piet Brozio, Marcin Chłoń, Laura Culí Verdaguer, Sebastian Dieck, Markéta Havlíková, Ramón Fábregas Valcarce, Francisco Jose Martinez Fernandez, Oliver Michael, Šárka Msallamová, Eni Soriano, Markus Wilke).

den Konzentration des Kupferabbaus in wenigen Gebieten. Die nachgewiesenen Bergbauregionen des 2. Jts. v. Chr. sind deutlich weniger zahlreich, dürften dafür aber von weit größerer Bedeutung gewesen sein. Allein diese *Konzentration* der Produktionsgebiete muss einen entscheidenden Einfluss auf den Produktionswert und alle weiteren Wertformen der Beile und Äxte gehabt haben. Ihre Abbau- und Herstellungsprozesse wurden mit der Zeit nicht nur standardisierter, ebenso wie ihre mechanischen Eigenschaften, sondern die Distributions- und Tauschnetzwerke mussten notwendigerweise entschieden erweitert werden, um Zugang zu den wirtschaftlich und militärisch immer wichtiger werdenden Artefakten zu gewährleisten. Erst mit dem Aufkommen der Eisenverhüttung, einem weitverbreiteten und, man könnte sagen, »demokratischen« Metall im Vergleich zu Kupfer und vor allem Bronze, konnte diese Konzentration von Ressourcen und damit von Macht überwunden werden. Der Vergleich mit der Vorgeschichte Afrikas südlich der Sahara, wo es den Gesellschaften gelang, direkt von einer nomadischen Lebensweise in die Eisenzeit zu wechseln, ohne eine ca. 2000–3000 Jahre lange Kupfer- und Bronzezeit zu durchlaufen, zeigt vielleicht am besten, wie entscheidend diese Periode für die Entwicklung von Wertbegriffen und, damit

einhergehend, Wertverteilung in Eurasien war, die vielleicht nur unsere Wirtschaftstheorien und Gesellschaft als angemessen verstehen.

Ausblick

Frühere Tagungen zu Äxten und Beilen haben regelmäßig auf Stein- oder Metallgeräte fokussiert. Der Mitteldeutsche Archäologentag (Abb. 5) führte als Novum beide Forschungsfelder zusammen und sorgte – auch nach Aussage der Teilnehmenden in der Abschlussdiskussion und vielen Gesprächen am Rande – für einen fruchtbaren Austausch und ganz neue Perspektiven auf das eigene Untersuchungsmaterial. Es stellt sich heraus, dass viele Aspekte des sozialen Umgangs mit Äxten und Beilen materialunabhängig – freilich mit Nuancierungen und regionalspezifischen Ausprägungen – diachron betrachtet werden können. Diese neue Perspektive verspricht zahlreiche neue Erkenntnisse auch für zukünftige Forschungen.

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Für die großartige Organisation der Tagung danken wir Claudia Gärtner und den zahlreichen Hilfskräften sowie der Martin-Luther-Universität Halle-Wittenberg und dem Verein zur Förderung des Landesmuseums für Vorgeschichte Halle (Saale) e. V. für deren große Unterstützung bei der Durchführung.

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Abbildungsnachweis/*Source of figures*

1 A. Swieder, A. Schuchardt, B. Janzen (alle LDA); base map: made with Natural Earth;free vector and raster map data @ natural earthdata.com

2–4 A. Swieder, LDA; base map: made with Natural Earth; free vector and raster map data @ natural earthdata.com

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NEOLITHIKUM

NEOLITHIC

Vollständiges Beil, gefunden bei Shulishade auf der Isle of Lewis, Äußere Hebriden (Schottland). Besonders ist neben der guten Holzerhaltung die importierte Klinge aus Antrim-Porzellanit (s. Beitrag Sheridan in diesem Band)

Complete axe found at Shulishader on the Isle of Lewis, Outer Hebrides (Scotland). In addition to the good preservation of the wood, the imported Antrim porcellanite axehead is a special characteristic (cf. Sheridan in this volume).

Exchanging fur and skin for shoe-last axes – Exploring the emergence of value, specialised hunting camps, and hunter-gatherer complexity in the Late Ertebølle Culture during the 5th millennium BC

Lasse Vilien Sørensen and Mads Lou Bendtsen

Zusammenfassung

Tausche Felle und Häute gegen Schuhleistenkeile – Eine Untersuchung zum Aufkommen von Wertigkeit, zu spezialisierten Jagdlagern und der Komplexität des Jäger-Sammler-Lebens in der späten Ertebølle-Kultur im 5. Jt. v. Chr.

Dieser Beitrag behandelt den Tausch von Schuhleistenkeilen aus Ackerbaugesellschaften in Nordeuropa und die Wirkung dieser fremdartigen Objekte auf die Jäger-Sammler-Gemeinschaften der späten Ertebølle-Kultur. Ein besonderer Schwerpunkt liegt darauf, ob diese Schuhleistenkeile im 5. Jt. v. Chr. im Rahmen eines Tauschnetzwerks zwischen Jägern und Sammlern und benachbarten Ackerbaugemeinschaften gegen Felle und Geweihe eingehandelt wurden. Das Aufkommen neuer, spezialisierter Jagdlager, die sich durch die große Anzahl der Nachweise von Pelztieren sowie Reh und Rothirsch auszeichnen, lässt sich am Beispiel einiger spätertebøllezeitlicher Fundplätze beobachten, die zeitgleich waren mit der Zunahme an Schuhleistenkeil-Importen. Handelt es sich dabei um die kommerzielle Antwort der Jäger und Sammler auf die Nachfrage der Ackerbaugemeinschaften nach Fellen und Geweihen sowie auf das eigene Verlangen nach Schuhleistenkeilen?

Einige der Schuhleistenkeile weisen so gut wie keine Gebrauchsspuren auf. Dies deutet darauf hin, dass sie Prestigeobjekte waren. Die meisten Schuhleistenkeile von spätertebøllezeitlichen Fundorten tragen jedoch Spuren von funktionellem, meist starkem Gebrauch. Sie wurden möglicherweise als Keile bei umfangreichen und intensiven Holzarbeiten eingesetzt. Der Bau größerer Hüttenstrukturen hätte es erlaubt, zu bestimmten Zeiten im Jahr mehr Menschen zu versammeln. Längere Einbäume hätten die logistischen Möglichkeiten verbessert, Waren über größere Entfernungen zu transportieren und das Tauschnetzwerk dieser Jäger und Sammler zu erweitern. Der Bau großer, ortsfester Fischreusen sicherte einen höheren wirtschaftlichen Überschuss dieser Jäger-Sammler-Gesellschaften. Änderungen bei diesen Praktiken sprechen dafür, dass die Jäger-Sammler-Gemeinschaften komplexer wurden – und zwar zeitgleich mit der Zunahme an direkten und indirekten Kontakten mit den benachbarten Ackerbaugemeinschaften in Nordeuropa. Die Schuhleistenkeile und ihr Tausch werden als Vermittler der Veränderung verstanden; und das Geschäft mit diesen Werkzeugen könnte bei den Jäger-Sammler-Gemeinschaften zur Ausbildung einer Tausch-

Summary

The exchange of shoe-last axes from agrarian communities in Northern Europe and the impact these exotic objects had upon the hunter-gatherer communities of the Late Ertebølle Culture is discussed in this article. Particular emphasis is placed upon the question whether these shoe-last axes were exchanged for fur and antler between hunter-gatherers and their neighbouring agrarian communities in an exchange network during the 5th millennium BC. The appearance of new specialised hunting camps characterised by the dominance of fur-bearing animals and roe and red deer can be observed at some Late Ertebølle sites, which is synchronous *with the increase in the importation of shoe-last-axes. Is this changed behaviour the hunter-gatherers' commercialised response to the demands of agrarian communities to acquire fur and antler, combined with the hunter-gatherers' own desire to gain access to the shoe-last axes?*

Some of the shoe-last axes show almost no signs of usage, indicating they were of prestigious status, but most of the shoe-last axes found at the Late Ertebølle sites show signs of functional, typically heavy, usage and were possibly used as wedges in large-scale and more intensive wood working. The building of larger hut structures would have improved the possibilities of gathering more people during specific times of the year. Longer dug-out canoes would have increased the logistical possibilities of transporting goods over greater distances and expanded the exchange networks of these hunter-gatherers. The construction of large, stationary fishing traps secured an increased economic surplus within these hunter-gatherer societies. The behaviour of these practices suggests that hunter-gatherer communities became more complex, a process which was synchronous with increased direct and indirect contacts with neighbouring agrarian communities in Northern Europe. The shoe-last axes and their exchange are interpreted as mediators of change, and the transactions of the axes could lead to a barter economy and a new awareness of the concept of value within these hunter-gatherer communities.

More studies of the scale of the different exchanged objects between agrarian and hunter-gatherer communities are, however, needed in order to confirm the initial observations and interpretations in this article.

wirtschaft und zu einem Bewusstsein für das Konzept von Wertigkeit geführt haben.

Weitere Untersuchungen zum Ausmaß des Tauschs verschiedener Objekte zwischen den Ackerbau- und den Jäger-Sammler-Gemeinschaften sind jedoch vonnöten, um die in diesem Beitrag geschilderten Beobachtungen und Interpretationen zu bestätigen.

Schlagwörter Späte Ertebølle-Kultur, Schuhleistenkeile, spezialisierte Jagdlager, Tauschwirtschaft, Wertigkeit, komplexe Jäger-Sammler-Gemeinschaften

Keywords Late Ertebølle Culture, shoe-last axes, specialised hunting camps, barter economy, value, complex hunter-gatherers

Introduction

This paper explores whether shoe-last axes from Central European agrarian societies could have been exchanged for fur and skin by hunter-gatherers of the Late Ertebølle Culture. In empirical terms, the point of departure is to combine the appearance of exotic shoe-last axes with the emergence of specialised hunting camps dominated by a faunal material of fur-bearing animals and red and roe deer during the second half of the 5th millennium BC in Southern Scandinavia. At a theoretical level, we discuss whether the exchange of shoe-last axes for fur, skin, and antler reflects a previously undiscovered awareness of the value of prestigious objects that emerged within a barter economy between agrarian and hunter-gatherer communities. And did these systems of large network exchanges of prestigious objects lead to an increased social and economic complexity and diversity within these egalitarian hunter-gatherer communities that has previously been underestimated?

The enigma of complex hunter-gatherers

The emergence of complex hunter-gatherers, defined by resource management, territoriality, and hierarchy, has, although difficult to document in the archaeological data, often been associated with the Late Ertebølle Culture in Southern Scandinavia[1]. P. Wiessner (2002) argued, based on the oral histories of the Enga of highland New Guinea, that the initial signs of complex hunter-gatherers are the quest for the institutionalisation of hierarchical social inequalities. The Enga economy was transformed from hunting and fishing towards surplus production based on the introduction of sweet potatoes and intensive pig husbandry. The result was population growth and the sharing of power between many different actors consisting of skilled hunters, traders, warriors, ritual specialists, and managers of power. These actors all acknowledged the emergence of increasing hierarchy led by the few with a focus on economic growth, although some communities were more successful than others in accumulating a surplus. As a result, a growing competition for prestigious objects between the communities could be documented as causing changes and different behaviour, thus setting the stage for more complex social organisations.

What can we learn from the observations of the Enga? Some signs of complex hunter-gatherers could be identified in the marked changes of their behaviour expressed in new practices, thus revealing what communities would do to get access to prestigious objects through a larger exchange system of exotic goods[2]. Exotic and prestigious objects become ›mediators of change‹ within such hunter-gatherer communities, thus gradually transforming the complexity of societies from an egalitarian to a more economically stratified and hierarchical character, with increasing amounts of material being exchanged within larger networks (Kohler/Smith 2018; Moreau 2020). The indirect or direct contact between the Late Ertebølle Culture and neighbouring agrarian societies did result in exchanges of exotic shoe-last axes[3]. The question is whether these shoe-last axes were regarded as prestigious when exchanged via several actors, where the value and desirability of the objects could change in other systems of exchange, depending on different cultural preferences (Wobst 1977; Latour 1996) (Fig. 1).

Assessing the value of exotic objects

The central and often overlooked concept in the emergence of complex hunter-gatherers is their awareness of different kinds of value and the assumption of a progression towards an economic way of thinking (Price/Feinman 2010). In classic economic thinking, objects either have an inherent value or their value is the result of either the labour or the degree of usefulness and circulation of goods, giving rise to many other concepts, such as surplus gains and profits, debt, and inequality (Appadurai 1986). This involves a new awareness of the desire, time, and labour invested in finding, procuring, and producing objects of high quality and/or beauty (Graber 2001). A fundamental problem relates to the question of how value as a concept was estimated within both an agrarian and a hunter-gatherer system, and how it could be related to physical objects like shoe-last axes.

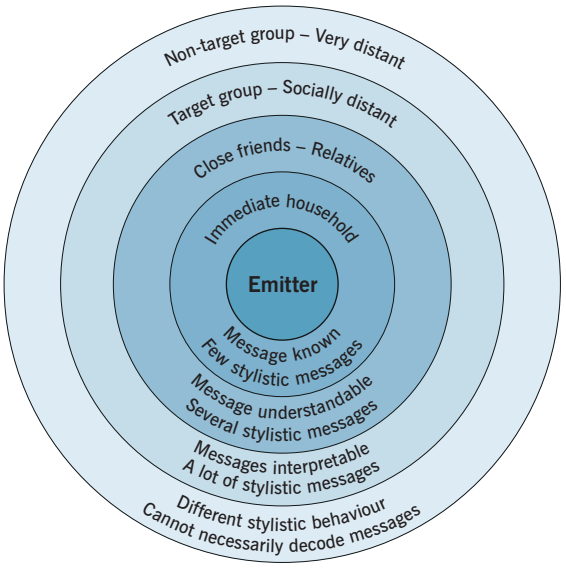
1 Price 2000; Johansen 2006; Sørensen 2014; Price 2022; Meyer 2023.

2 Sahlins 1972; Appadurai 1986; Graber 2001; Malafouris 2013.

3 Fischer 1982; Fischer 1983; Klassen 2004; Jensen/Sørensen 2023.

Fig. 1 The meaning behind an object or information within a network decreases from a target group to a non-target group.

Abb. 1 *Die Bedeutung eines Objekts oder einer Information nimmt innerhalb eines Netzwerks von einer Zielgruppe zu einer Nicht-Zielgruppe ab.*



In the human mind, certain desirable objects could transform themselves to become commodities, thus resulting in a consensus regarding their value, so they were suitable for circulating through economic systems and being exchanged for other things (Kopytoff 1986). I. Kopytoff supports the idea of the emergence of the commodification of objects, where some types of objects are mass produced using the same raw materials, thus becoming recognisable to the human mind. The consequence is singularising and consensus regarding the value of these objects in some exchange systems. The challenge is that value varies and is thus a dynamic concept in which objects can acquire individual characters and achieve different kinds of value. It is therefore a challenge to determine the value of objects like the shoe-last axes, as this is based on the reciprocal relationship of objects within the individual human minds involved when evaluating several objects and their properties in relation to one another (Simmel 1900). Value – whether use-value or symbolic, social, or economic value – is a culturally constructed quality, which becomes embodied in commodities when they are exchanged and is thus considered to be context dependent[4].

A way forward attempted in this paper would be to search for changed behaviour within the context of the Late Ertebølle Culture after the foreign shoe-last axes entered this hunter-gatherer exchange system. Based on the theoretical implications of value as well as the emergence of complexity, such behavioural changes should be expected if the shoe-last axes were regarded as highly valuable and prestigious within these Late Ertebølle communities.

The sources exploited to produce the shoe-last axes

The largest group of exotic and foreign objects within the Late Ertebølle Culture are the shoe-last axes, which are found in Southern Scandinavia from 4900 to around 4000 cal BC (Fig. 2). The shoe-last axes demonstrate a connection with the Linear Pottery, Stroke-Ornamented Ware, and Rössen agrarian communities[5]. The raw material of amphibole-rich metabasite was used to produce some of these shoe-last axes (Bernardini et al. 2012). Recently, the quarries for the metabasite were identified near Jistebsko in northern Bohemia in the Czech Republic (Šída/Kachlík 2009; Přichystal 2014, 192) (Fig. 2). The shoe-last axes were produced by Central European craft specialists from 5400 to 4600 BC and distributed within and beyond the agrarian networks covering large parts of Central Europe and further, towards the hunter-gatherer societies of the Swifterbant and Ertebølle Cultures (Klassen 2004; Raemaekers et al. 2010; Verhart 2012).

According to observations made by P. Šída (2007), the shoe-last axes produced at the Jistebsko source are characterised by a production involving mainly a pecking and polishing technique. Other shoe-last axes from Central Europe, made of both basalt and metabasite from unidentified sources, were made using a combination of sawing, pecking, and polishing techniques. The technological differences between the Jistebsko and some unidentified sources suggest that several sources were being exploited to produce shoe-last axes. The shoe-last axes found in Southern Scandinavia are characterised by the production technologies of both pecking and sawing (Lomborg 1962; Klassen 2004), which suggests that axes from both unidentified and the Jistrebsko source ended up in the hunter-gatherer exchange system of the Late Ertebølle Culture.

Distribution of the shoe-last axes in Northern Europe

The Linear Pottery, Stroke-Ornamented Ware, and Rössen agrarian communities needed large axes, such as the shoe-last axes, to work substantial timbers used, for example, to construct large trapezoidal longhouses, which were often over 60 m long (Luley 1990). The shoe-last axes therefore had an important symbolic meaning to some of the earliest Central European agrarian cultures and have been found in burials and hoards at settlements belonging to the Stroke-Ornamented Ware and Rössen agrarian communities (Klassen 2004; Müller 2023) (Fig. 2). The importance of the shoe-last axes can also be observed in the dense distribution of these objects, which also continued to be exchanged with Central European agrarian communities and which were spread towards the Ertebølle and Swifterbant hunter-gatherer societies after the exploitation of the source at Jistebsko ended around 4600 cal BC.

4 Appadurai 1986; Bradley/Edmonds 1993; Risch 2011; Borgerhoff Mulder et al. 2009.

5 Lomborg 1962; Schwabedissen 1967; Fischer 1982; Fischer 1983; Klassen 2004.

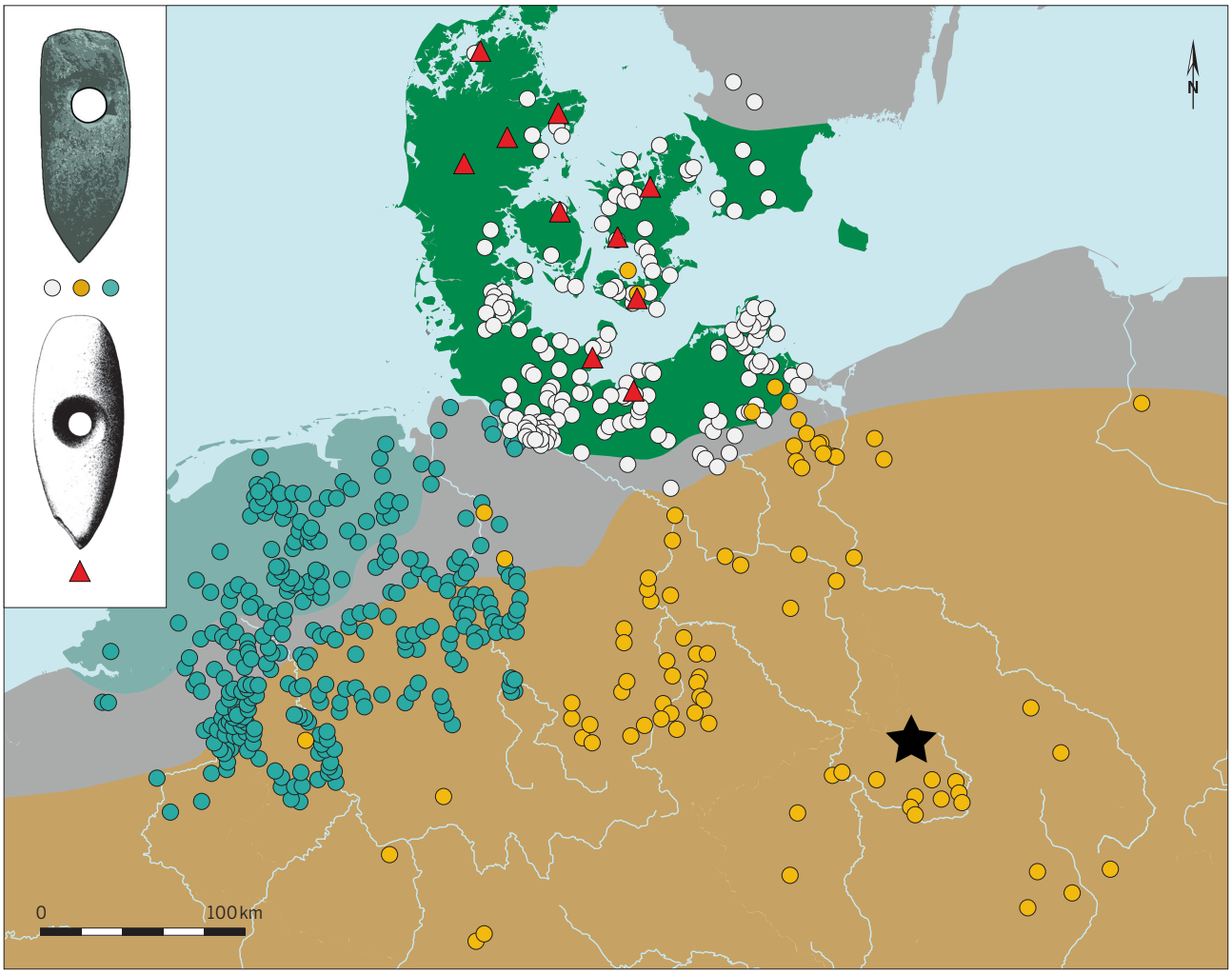


Fig. 2 Distribution of shoe-last axes (upper left; dots) in agrarian and hunter-gatherer societies in Europe together with local imitations within the Late Ertebølle Culture (bottom left; red triangles). Middle Neolithic hoards (yellow dot), together with the Ertebølle (white dot) and Swifterbant (green dot) Cultures, with the primary source of amphibole-rich metabasite near Jistebsko (black star) in Northern Bohemia, Czech Republic. Distribution of the Late Ertebølle Culture (dark green), Swifterbant Culture (light green), and Central European agrarian cultures (yellow). The grey zone is the contact area between the different hunter-gatherer and agrarian societies.

Abb. 2 *Verbreitung von Schuhleistenkeilen (oben links; Punkte) in Ackerbau- sowie Jäger-Sammler-Gesellschaften in Europa zusammen mit lokalen Nachahmungen innerhalb der späten Ertebølle-Kultur (unten links; rote Dreiecke). Mittelneolithische Hortfunde (gelber Punkt), Ertebølle-Kultur (weißer Punkt), Swifterbant-Kultur (grüner Punkt) und die Hauptquelle amphibolreicher Metabasite bei Jistebsko (dt. Gistey; schwarzer Stern) in Nordböhmen, Tschechische Republik. Verbreitung der späten Ertebølle-Kultur (dunkelgrün), der Swifterbant-Kultur (hellgrün) und der mitteleuropäischen Ackerbaukulturen (gelb). Die graue Zone ist der Kontaktbereich zwischen den verschiedenen Jäger-Sammler-Gesellschaften und den Ackerbaukulturen.*

The distribution of shoe-last axes indicates that they came to the Netherlands and Southern Scandinavia via the major Central European rivers, such as the Weser, Elbe, Saale, Oder, and other smaller tributaries running either into the North Sea, and via other land and river routes towards the Swifterbant Culture or into the Baltic Sea towards the Ertebølle Culture[6]. Several major concentrations of shoe-last axes have been observed in Lower Saxony (Lichardus 1976, 176) and Saxony-Anhalt (Kaufmann 2020, 392), which could represent the initial stages of the larger exchange systems towards the Swifterbant and Ertebølle Cultures.

However, many of these shoe-last axes probably existed within these agrarian and hunter-gatherer exchange systems for several hundred years, thus indicating their status, prestige, and value. According to the theories developed by A. Weiner (1992) about inalienable possessions, where she highlights the importance of keeping-while-giving, which means that some possessions can be exchanged as gifts in a balanced or unbalanced way, whilst other objects are so significant that they cannot be disposed of or exchanged, but must be retained within the communities, so that other things can circulate. Objects that cannot be exchanged at all constitute the fixed point of coherence within these communities, which can be used, destroyed, or sacrificed in symbolic rituals to maintain the social order (Godelier 1999). The emergence of such sacred objects associated with status and prestige creates a desire and demand, thus

6 Lichardus 1976; Klassen 2004; Raemaekers et al. 2010; Verhart 2012.

laying the foundation for increased and institutionalised competition between communities. Inspired by a combination of these theories and anthropological analogies, the shoe-last axes have been interpreted as prestigious objects, which were exchanged between Central European agrarian societies and Ertebølle hunter-gatherers (Fischer 1982; Fischer 2002; Jennbert 1984). The question is whether the status of shoe-last axes as prestigious objects also continued during several exchanges and influenced the hunter-gatherer communities of the Late Ertebølle Culture.

Shoe-last axes as prestigious and ordinary functional objects

According to the theories that have been proposed, the possession of shoe-last axes would have given increased status to the local Ertebølle hunter-gatherers who owned these objects. The systematic exchange of shoe-last axes with Ertebølle hunter-gatherers could therefore be interpreted as causing changes leading to a gradual transfer of agrarian ideas and ideology, and thus to an increasing complexity within these communities. But shoe-last axes have only been found in what have been interpreted as ordinary refuse layers at Late Ertebølle sites, which makes the interpretation of the axes as prestigious objects seem less plausible (Klassen 2004, 409). However, many of the ordinary waste deposits should be reinterpreted, as shoe-last axes have been found in layers or features containing decorated antler axes and scattered human bone fragments (Brinch Petersen 2001; Andersen 2008). Currently, there is no consensus about or clear distinction between the interpretations of normal refuse as opposed to deliberately destroyed objects or symbolic deposits (Sørensen 2020). It is therefore difficult to separate ordinary waste from symbolic deposits, but recent discoveries at the Femernbelt site of Syltholm II (Denmark) demonstrate that ordinary objects were deliberately deposited into the ground, along with a newly discovered shoe-last axe (Sørensen 2020b; Sørensen 2023).

Most of the shoe-last axes found in Late Ertebølle contexts show significant use-wear and damage to the neck, thus indicating a purely functional usage in, for example, heavy wood working (Klassen 2004; Raemaekers et al. 2010). But there are also a few examples of shoe-last axes, such as the one found recently in connection with the Femernbelt excavations at Syltholm II, which show limited signs of heavy usage. No use-wear analyses have so far been conducted on the shoe-last axes from Late Ertebølle contexts, which could reveal whether some of the objects had been associated with prestige or with more domestic activ-

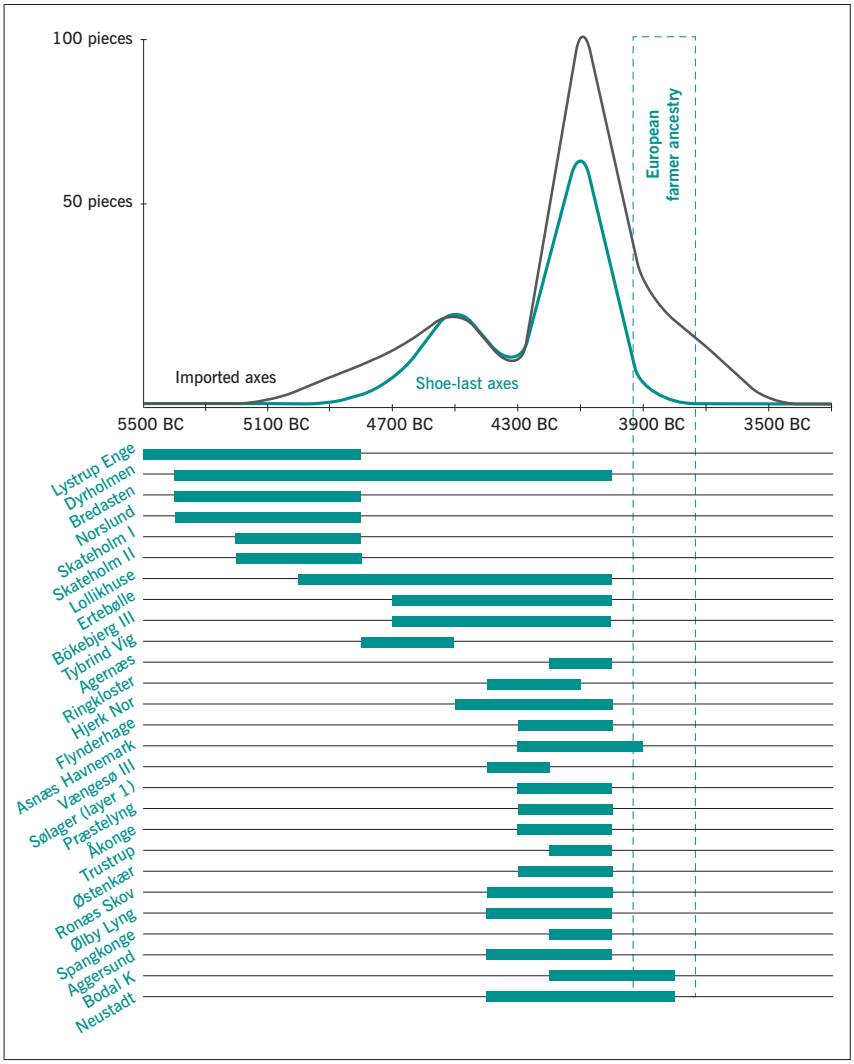


Fig. 3 Radiocarbon dates of Late Ertebølle sites containing substantial amounts of faunal material, combined with the import and exchange of shoe-last axes and other exotic axes, from the 5th millennium BC in Southern Scandinavia.

Abb. 3 *Radiokarbondaten von spätertebøllezeitlichen Fundorten mit umfangreichem tierischen Material in Kombination mit dem Import und Tausch von Schuhleistenkeilen und anderen fremden Äxten/Beilen des 5. Jts. v. Chr. in Südskandinavien.*

ities (Skak-Nielsen 2007). Personal circumstances and preferences of the hunter-gatherer communities probably played important and dynamic roles in defining what were perceived as normal or more symbolic activities, and when objects could be associated with power and status or perceived as ordinary domestic items (Sørensen 2012; Sørensen 2020b). Here, future use-wear studies combined with the investigations of the contextual information are of crucial importance.

Local imitations of shoe-last axes

Another problem associated with the interpretation of shoe-last axes as prestigious objects is the lack of local imitations of these axes. If the ownership of such axes was associated with increased status and the objects functioned as powerful mediators of certain ideas, then local imitations would be expected. Such imitations, although very rare, do exist, especially at Late Ertebølle sites in Southern Scandinavia and Northern Germany, where the type has been observed at Ertebølle, Ringkloster, Vængesø II–III, Agernæs, Kassemose, Romvig, Vester Ulslev, Karrebæk (all Denmark), Rosenhof and Timmendorf-Nordmole (both Germany; Andersen 1998; Andersen 2018; Klassen 2004, 132) (Fig. 2). The local imitations of shoe-last axes are often made of diabase or gabbro, with a central, biconical, and hourglass-shaped shaft hole, which is pecked. They vary in size, with a length ranging from 15 to 23 cm, a width of up to 10 cm, and a thickness of as much as 7 cm, as was the case in one example from the Late Ertebølle site of Vængesø II (Andersen 2018, 181).

In general, the limited number of imitations of the shoe-last axes could indicate that the idea behind the axes, as items of prestige and status, may have been lost in a Mesolithic network of contacts. If an artefact is exchanged indirectly several times and reaches marginal regions of a network, then the original meaning behind the object can be lost and change to something different (Wobst 1977; Latour 1996) (Fig. 1). Such an interpretation may apply, but the fact that local imitations exist points towards a demand for the shoe-last axes and difficulties in obtaining access to such exotic objects within the Late Ertebølle exchange networks. An increasing desire to gain access to shoe-last axes could have resulted in altered behaviour within the Late Ertebølle communities in their response to Southern Scandinavian demands for specific goods from either neighbouring hunter-gatherers in Northern Germany or agrarian communities in Northern Europe.

The appearance of shoe-last axes and changed hunting behaviour in the Late Ertebølle Culture

During the Ertebølle Culture from 4900 to 4000 cal BC, an increasing importation of the foreign shoe-last axes together with other exotic axes (adzes as well as disc and pointed-butted axes) can be observed in Southern Scandinavia, which reached its peak during the period of 4300–4000 cal BC, right at the end of the Late Ertebølle Culture (Klassen 2004, 101). Some of the many sub-types of shoe-last axes classified by Klassen (2004, 24 ff.) have, in other studies, instead been interpreted as the result of continuous resharpening processes, rather than representing actual types (Raemaekers et al. 2010; Müller 2023). Nevertheless, the appearance of the earliest shoe-last axes is supported by an AMS date (4941–4729 cal BC) for the shaft that was preserved in the hole of a shoe-last axe from Rosenhof LA 58, thus indicating the starting point of the appearance of the shoe-last axes in the Late Ertebølle Culture (Hartz 2004; Hartz et al. 2007). Although more direct AMS dates are needed for the contexts the shoe-last axes have been found in, the general trend of increasing importation of the shoe-last axes culminating in a peak at the end of the Ertebølle Culture seems to apply (Klassen 2004; Sørensen 2014) (Fig. 3).

In addition, from around 4700 to 4000 cal BC, changed behaviour within the Late Ertebølle Culture can be observed in the form of new specialised hunting camps. At these sites, there was an increased focus on exploiting fur-bearing animals on a much larger scale than has previously been observed. The animals being hunted and systematically slaughtered were especially beaver *(Castor fiber)*, wild cat *(Felis silvestris)*, otter *(Lutra lutra)*, pine marten *(Martes martes)*, fox *(Vulpes vulpes)*, and lynx *(Lynx lynx)*. These new practices can be observed at sites such as Ringkloster, Agernæs, Tybrind Vig, Hjerk Nor, and Bodal K (all Denmark; Richter/Noe-Nygaard 2003; Hatting et al. 1973; Gotfredsen 2003) (Fig. 4).

Another changed behaviour during the Late Ertebølle Culture, also from around 4700 to 4000 BC, is an increase in the hunting of roe *(Capreolus capreolus)* and red deer *(Cervus elaphus)*, as observed at several sites, including Bökebjerg III, Agernæs, Ringkloster, Asnæs Havnemark, Præstelyng, Åkonge, Østenkær, Spangkonge, Bodal K, and Smakkerup Huse (all Denmark; Fig. 5)[7]. The aim of these hunter-gatherers was clearly to exploit the meat, bone, and antler as well as the highly-quality skins of these animals, and the hunting also included newborn roe and red deer calves, the skin of which is of superb quality.

Exchanging fur for shoe-last axes?

Such specialised hunting camps may have resulted from a growing demand for foreign shoe-last axes within the Late Ertebølle Culture, which in a barter economy could be exchanged for fur and skin. If the skin was exchanged to agrarian communities as finished products, then it could explain how amber beads, shell buttons, and perhaps even grandeln teeth of red deer or even T-shaped antler axes from the Late Ertebølle Culture may have spread to the agrarian societies in Central Europe during the late 5th millennium BC (Bogucki 2008, 55–56; Heumüller 2012; Row-

7 Eriksson/Magnell 2001; Richter/Noe-Nygaard 2003; Price 2022; Noe-Nygaard 1995; Gotfredsen 1998; Gotfredsen 2003; Enghoff 2011; Price/Gebauer 2005.

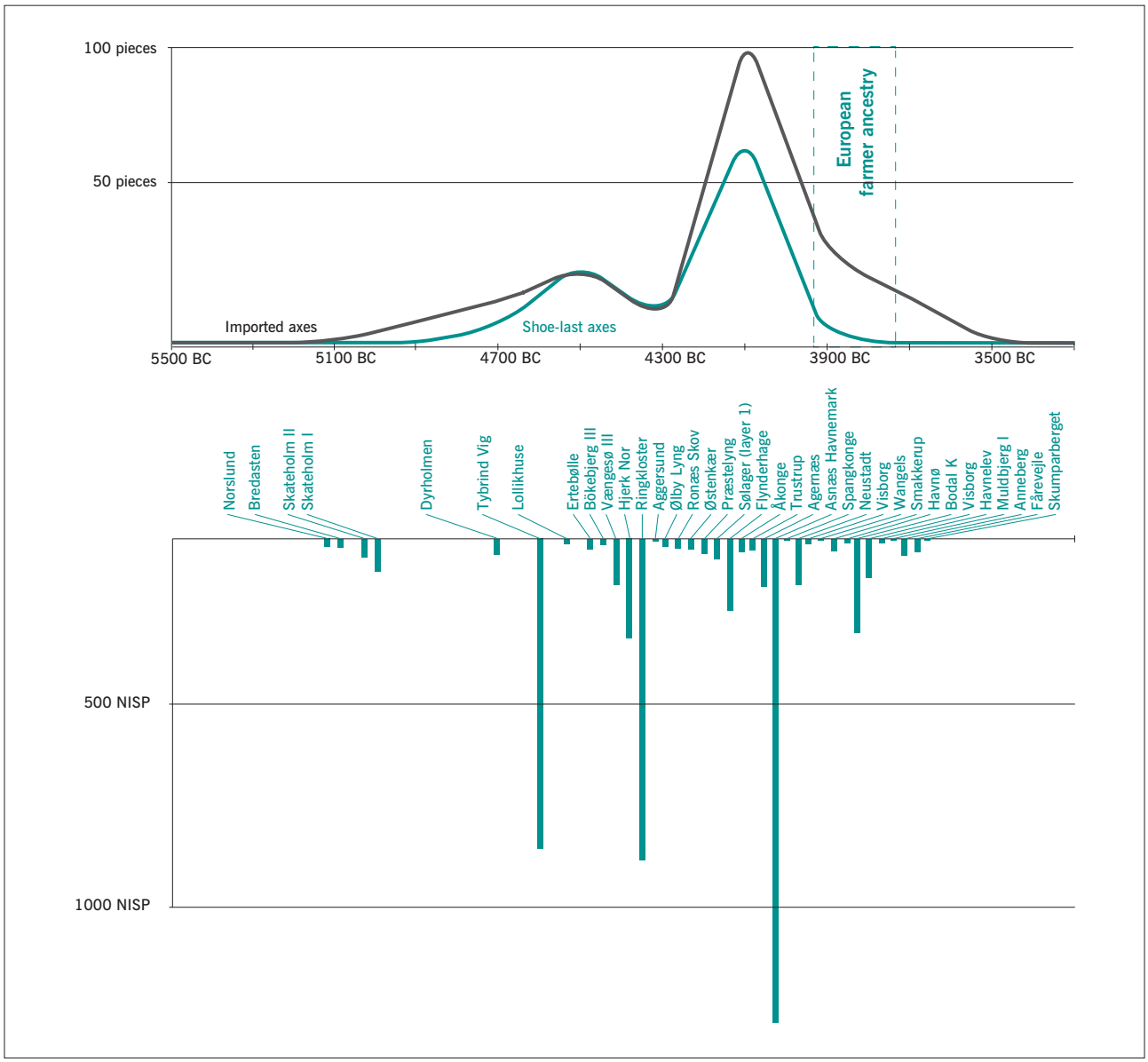


Fig. 4 The NISP values (Number of Identified Specimens) of fur-bearing animals beaver *(Castor fiber)*, wild cat *(Felis silvestris)*, otter *(Lutra lutra)*, pine marten *(Martes martes)*, fox *(Vulpes vulpes)* and lynx *(Lynx lynx)* from Late Ertebølle sites, combined with the import and exchange of shoe-last axes and other exotic axes from the 5th millennium BC in Southern Scandinavia.

Abb. 4 *NISP-Werte (Anzahl der identifizierten Exemplare) von Pelztieren: Europäischer Biber* (Castor fiber), *Europäische Wildkatze* (Felis silvestris), *Fischotter* (Lutra lutra), *Baummarder* (Martes martes), *Rotfuchs* (Vulpes vulpes) *und Eurasischer Luchs* (Lynx lynx) *von spätertebøllezeitlichen Fundorten in Kombination mit Import und Tausch von Schuhleistenkeilen und anderen fremden Äxten/Beilen des 5. Jts. in Südskandinavien.*

ley-Conwy 2014, 196). The wider exchange networks of the Late Ertebølle Culture objects found within agrarian communities in Northern Europe could be interpreted as a commercialisation process, in which these hunter-gatherers in Southern Scandinavia reorganised their economy to meet the demands of agrarian communities, with their commercial interests further afield involving many exotic objects, including fur, as proposed by M. Zvelebil (2001, 7).

The exchanges involving the shoe-last axes could either have been indirect, with neighbouring hunter-gatherers across the Baltic Sea, along the North German coast – at sites like Rosenhof, Neustadt, Siggeneben-Süd, and Wangels –, or direct, with agrarian communities located further inland in Central Europe (Fig. 6). Direct exchanges between Late Ertebølle hunter-gatherers and pioneering farmers from Central Europe could also have occurred during their scouting visits to Southern Scandinavia. Evidence of such direct contact with pioneering Central European agrarian communities is associated with the two axe hoards from Udstolpe (Denmark), containing one pointed-butted axe and two shoe-last axes (Lomborg 1962) (Fig. 7), and with the Askø hoard (Denmark), containing two shoe-last axes (Jensen/Sørensen 2023; Müller 2023), which point towards occasional visits by scouting farmers to Southern Scandinavia (Anthony 1990; Sørensen 2014; Gron/Sørensen 2018).

Axe deposits of shoe-last axes are usually found in Central European agrarian societies and may have been symbolic offerings made by scouts searching for new territories and exchanging specific objects with the ingenious hunter-gatherers in the north (Sørensen 2020; Gebauer/

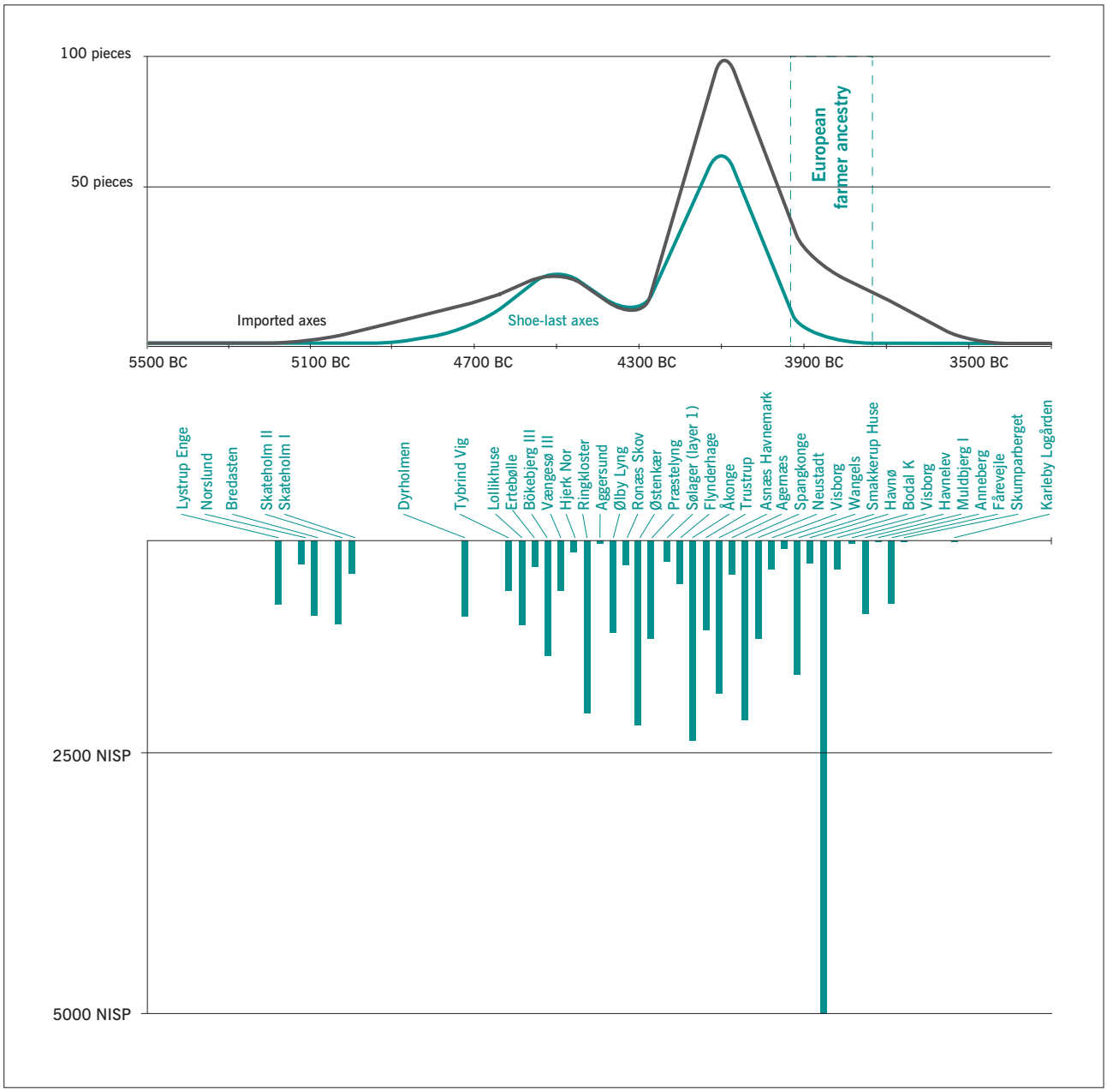


Fig. 5 The NISP values (Number of Identified Specimens) of roe (*Capreolus capreolus*) and red deer (*Cervus elaphus*) from Late Ertebølle sites, combined with the import and exchange of shoe-last axes and other exotic axes, from the 5th millennium BC in Southern Scandinavia.

Abb. 5 *NISP-Werte (Anzahl der identifizierten Exemplare) von Reh* (Capreolus capreolus) *und Rothirsch* (Cervus elaphus) *von spätertebøllezeitlichen Fundorten in Kombination mit Import und Tausch von Schuhleistenkeilen und anderen fremden Äxten/Beilen des 5. Jts. in Südskandinavien.*

Sørensen 2022; Müller 2023). The greatest concentration of shoe-last axes in Southern Scandinavia is located on Lolland-Falster (Denmark), where the Udstolpe and Askø hoards have been found. In the same region, other exotic stray finds have also been documented, such as an amphibolite disc macehead at Vejrø, a pointed-butted axe of Alpine jadeite on Lolland, and a copper flat axe from Vantore, which indicate that this is one of the regions that had continuous contact with agrarian communities in Central Europe (Klassen, 2004; Pétrequin et al. 2012).

Contact between Central European agrarian communities and the Late Ertebølle hunter-gatherers is also attested by the bone rings, which are imitations of the rings made of marble or amphibolite associated with the Rössen Culture (Andersen 1998). Bone rings have been found at various sites in Denmark dating to the Middle and Late Ertebølle Culture, from around 4600 to 4400 cal BC (Klassen 2004).

Another example of possible contact between local hunter-gatherers and pioneering agrarian scouts has been identified at the site of Dąbki 9 in North Poland. The site was characterised by large quantities of beaver bones and was therefore interpreted as a beaver-hunting station, with an additional amber workshop (Hartz et al. 2015; Schmölcke/Nikulina 2015). Agrarian groups from the Bodrogkeresztúr Culture may have visited the Baltic coast and exchanged amber and beaver furs for domesticated animals, Neolithic pottery, and copper artefacts with hunter-gatherer groups living at Dąbki 9 (Kotula et al. 2015).

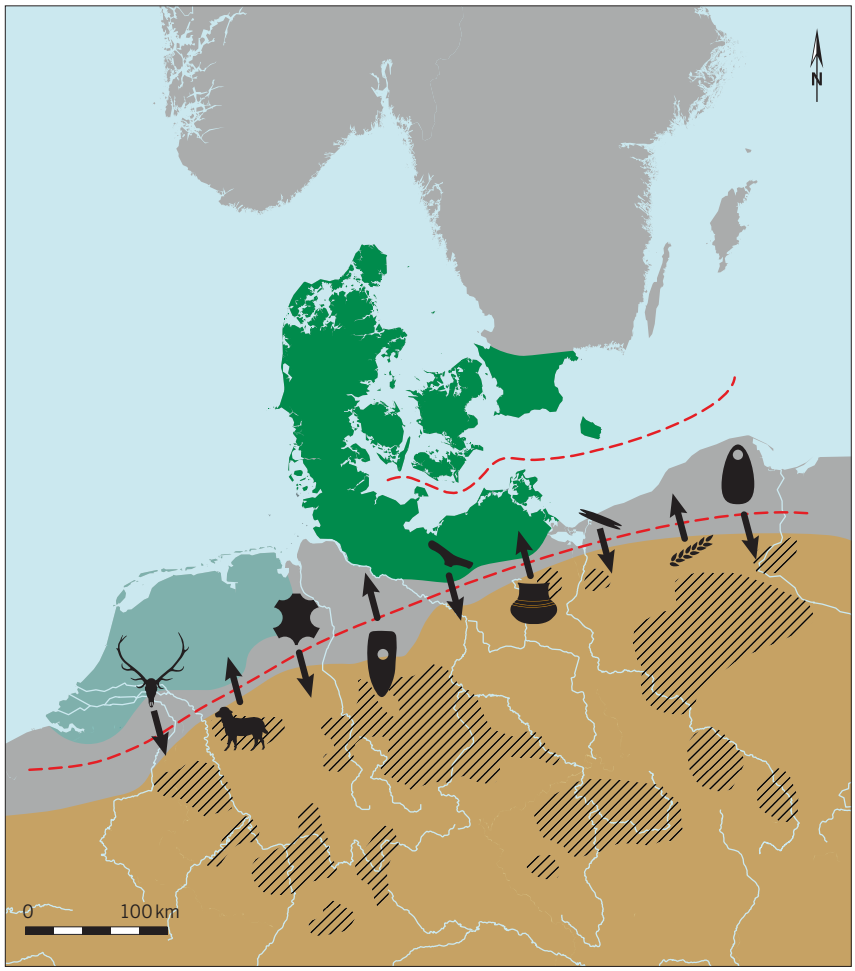


Fig. 6 Exchange of fur, T-shaped antler axes, shell buttons, and amber beads from hunter-gatherers in Southern Scandinavia and Northern Germany with shoe-last axes, Neolithic pottery and domesticated animals from the neighbouring agrarian communities in Northern Europe. Border zones are marked in the Baltic Sea and Northern Germany between hunter-gatherer groups (dashed red lines), which may have had direct and indirect contact with agrarian communities. Distribution of the Late Ertebølle Culture (dark green), Swifterbant Culture (light green), and Central European agrarian cultures (yellow). The grey colour is the contact zone between the hunter-gatherer and agrarian societies. The black hatching marks areas of loess sediments, where a high concentration of agrarian sites and activities have been documented.

Abb. 6 *Tausch von Fellen, T-förmigen Geweihäxten, Muschelknöpfen und Bernsteinperlen von Jägern und Sammlern in Südskandinavien und Norddeutschland gegen Schuhleistenkeile, neolithische Keramik und domestizierte Tiere von benachbarten Ackerbaugemeinschaften in Nordeuropa. In der Ostsee und in Norddeutschland sind Grenzzonen zwischen Jäger-Sammler-Gruppen markiert (rote Strichlinien), die möglicherweise direkten und indirekten Kontakt zu den Ackerbaugemeinschaften hatten. Verbreitung der späten Ertebølle-Kultur (dunkelgrün), der Swifterbant-Kultur (hellgrün) und der mitteleuropäischen Ackerbaukulturen (gelb). Die graue Farbe stellt die Kontaktzone zwischen den Jäger-Sammler-Gesellschaften und den Ackerbaukulturen dar. Die schwarze Schraffur kennzeichnet Gebiete mit Lösssedimenten, in denen eine hohe Konzentration von Ackerbaustandorten und -aktivitäten dokumentiert wurde.*

Fig. 7 Deposition of two shoe-last axes and one pointed-butted stone axe of metabasites from Udstolpe, Lolland (Denmark).

Abb. 7 *Depotfund zweier Schuhleistenkeile und eines Spitznackenbeils aus Metabasit aus Udstolpe, Lolland (Dänemark).*

Fig. 8 Shoe-last axes from the Late Ertebølle Culture on Zealand (Denmark) with considerable damage to the butt and cutting edge, which could be evidence of use in heavy woodworking activities.

Abb. 8 *Schuhleistenkeile der späten Ertebølle-Kultur auf Seeland (Dänemark) mit starken Beschädigungen am Nacken und an der Schneide, die auf die Verwendung bei schweren Holzarbeiten hinweisen könnten.*

It is tempting, based on this changed hunting behaviour within the Late Ertebølle Culture, to draw an analogy with the Native American fur trade: here, fur and deerskin commodities were also exploited to a much greater extent by the Native Americans and exchanged for exotic goods, such as guns, pearls, and metal, when the incoming European settlers came to North America. This provides an interesting parallel from the ethnographic and historic records (Pavao-Zuckerman/Reitz 2006; Pavao-Zuckerman 2007).

The conceptual and practical impact of the exchange of shoe-last axes

If the idea is accepted that there was a connection between the hunter-gatherers' desire to gain access to the shoe-last axes and the resulting appearance of specialised hunting stations exploiting fur-bearing animals as well as roe and red deer in a barter-like exchange system, then objects would have begun to be associated with greater economic value. This would have revolutionised the mindset of these hunter-gatherer communities towards becoming more competitive, commercialised, and complex in their management of resources, as well as in their social organisation. The question is: Why did these hunter-gatherers require the exotic shoe-last axes, and could they have given their owners some practical advantages? One typical feature that can be observed on most of the shoe-last axes found in Late Ertebølle contexts is the significant use-wear and damage to the neck; this may indicate that these axes were used and had a special role in the heavy woodworking involved in important symbolic, logistic, and economic constructions (Fig. 8). Large house structures, which, based on the width of the postholes, consisted of very thick pieces of timber, were being built during the Late Ertebølle Culture; they covered an area of 30–70 m^2, and the larger houses in particular have been interpreted as winter houses (Grøn 2003). The construction of large hut structures would have made it possible to integrate several hunter-gatherer communities, possibly stimulating greater group identity, increased competition, and more network exchanges (Fig. 9).

A similar increase has been observed in the sizes of the dug-out canoes from the Late Ertebølle Culture, which are up to 10 m long. Such canoes could have been used to transport a number of people and considerable quantities of goods through the water routes in this maritime landscape and beyond towards the larger rivers running out into the Baltic Sea, helping maintain and expand the networks involved in various kinds of exchanges (Christensen 1990).

Interpretations of forest management have even been suggested in connection with the construction of large stationary fishing traps consisting of hundreds or perhaps even thousands of hazel stakes, which increase in intensity and size during the Late Ertebølle Culture. The stakes had been selected based on their thickness and were often around 3 cm in diameter, and therefore an average of seven years old (Christensen 1997). Furthermore, studies of their growth rings indicate that they were cut either in the spring

or autumn, suggests a harvesting pattern and thus forest management (Price 2022). Recently, the argument in favour of forest management during the Late Ertebølle Culture has been criticised, as hazel stakes can also be selected from natural openings in forests, and it has been stated that such management did not occur in the Late Mesolithic or the Neolithic (Out et al. 2020). Nevertheless, historical records indicate that the hazel stakes required to construct large stationary fish traps would have required large clearings in the forest, covering several hectares (Pedersen et al. 2018). Pollen diagrams also demonstrate that openings in the forest did exist during the Late Ertebølle Culture: The increase of ribwort plantain *(Plantago lanceolata)* and wild grasses before the elm decline indicate that there were possible clearings, which increased the areas available for hunting wild game (Göransson 1986; Kolstrup 1988; Regnéll 1989).

The construction of larger stationary fishing traps during the Late Ertebølle Culture would have secured a substantial economic subsistence surplus for these hunter-gatherers and perhaps also have resulted in an increase in territorial conflicts over the best fishing grounds and fjords between these hunter-gatherer communities (Fig. 10). Territories could have existed during the Late Ertebølle Culture, as has been proposed based on several different types of flake axes on Zealand (Vang Petersen 1984) and on various types of ornamentation on the painted or carved paddle blades in Eastern Jutland (Andersen 2013; Skriver et al. 2018).

Evidence of violence has also been observed in the form of cranial injuries, which have often been recorded on individuals within the Øresund region during the Middle-Late Mesolithic (Bennike 1985). Today, around 100 to 120 skeletons of a Mesolithic date are known from Southern Scandinavia, with around one in ten of these showing signs of serious injuries (Andersen 2015). Most skull injuries are observed in adult males, although some women also have serious injuries that were caused by violence. Most of the head injuries have healed, however, and only in three or four examples involving the individuals buried at Henriksholm-Bøgebakken, Vængesø II, Skateholm, and Tågerup (all Denmark) has the violence indicated by the evidence appeared fatal (Sørensen/Nielsen 2024). It is, however, difficult to assess the amount of violence in the latest part of the Ertebølle Culture, as burials disappear after 4700 BC, subsequently consisting of loose human remains found at the different settlements (Sørensen 2016). Nevertheless, there are signs which could be interpreted as an emerging complexity within these hunter-gatherer societies, where they were building larger wood constructions, which were meant to last for generations.

All these examples demonstrate that woodworking involving large timbers intensified during the Late Ertebølle Culture, with the shoe-last axes perhaps the main tool that was used in such activity. Moreover, when such foreign objects were used, they may also have had symbolic meaning, as such shoe-last axes could have been carriers of stories of past owners, places, and constructions, thus functioning as mediators of a new kind of ideology that was embedded in them (Chapman 2000; Bradley 2005). A recent study of the decorated antler axes indicates that the decoration of these objects stops around 4700 cal BC, and they become an undecorated tool at the beginning of the Late Ertebølle Culture, which is also the time when the shoe-last axes are being imported (Andersen 2023). After this, decorations during the Late Ertebølle Culture are observed on pottery and painted or carved paddle blades. Another major change that occurs around 4700 cal BC is a significant decline in burials and an increase in loose human bones at the habitation sites (Sørensen 2016).

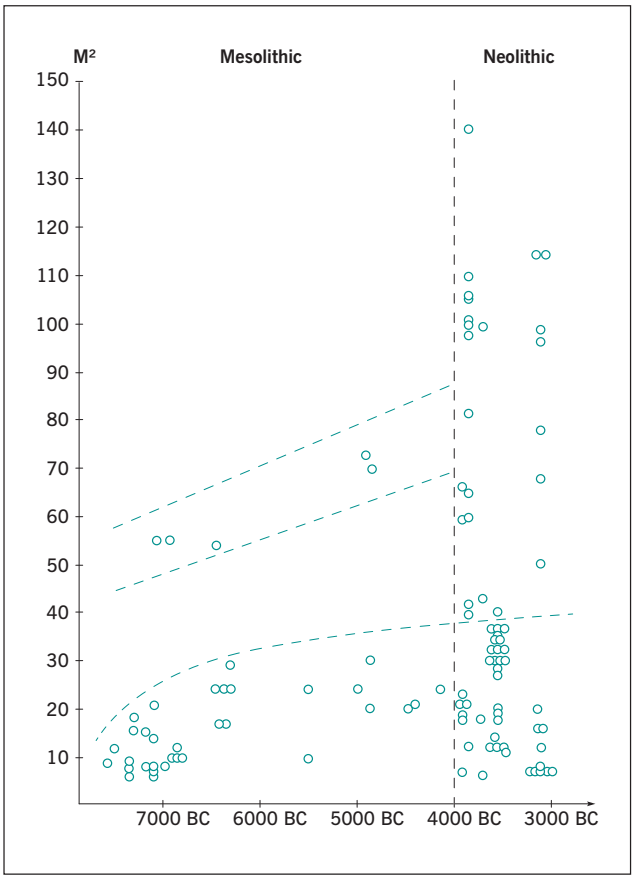


Fig. 9 Estimated floor space areas of dwellings (circles) over time from the Mesolithic to the Early Funnel Beaker Culture in Southern Scandinavia. The dashed lines mark the possible summer huts below 30 m², while larger hut structures above 50 m² mark the possible winter huts.

Abb. 9 *Geschätzte Grundflächen von Wohnbauten (Kreise) im Laufe der Zeit vom Mesolithikum bis zur frühen Trichterbecherkultur in Südskandinavien. Die gestrichelten Linien markieren die möglichen Sommerhütten unter 30 m², während größere Hüttenstrukturen über 50 m² die möglichen Winterhütten markieren.*

All these changes reflect an important shift in burial practices, and thus also in fundamental social and ideological changes, which are synchronous with the appearance of new objects in the material culture, such as pottery, T-shaped antler axes, bone rings, and shoe-last axes. The shoe-last axes can clearly be regarded as an agent and mediator of change at both a conceptual and practical level within these hunter-gatherer communities in the Late Ertebølle Culture.

Concluding remarks

One of the ideological causes of change was the Late Ertebølle hunter-gatherers' direct or indirect interaction

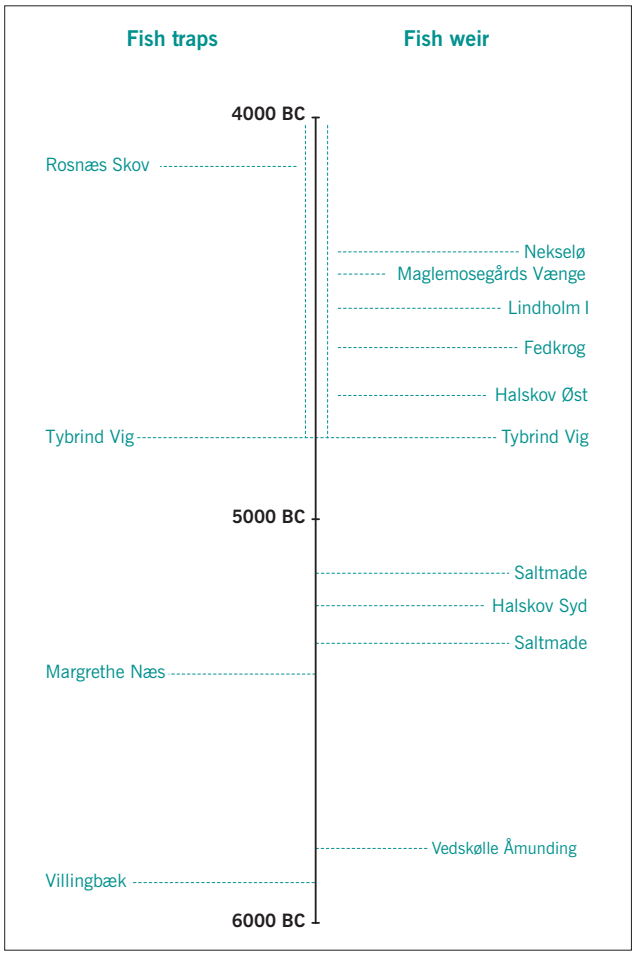


Fig. 10 Overview of the stationary fish traps from the Ertebølle Culture in Southern Scandinavia.

Abb. 10 *Übersicht der ortsfesten Fischreusen der Ertebølle-Kultur in Südskandinavien.*

with the Central European agrarian communities in connection with the exchange of fur and skin for shoe-last axes. Such transactions could lead to a barter economy and a new awareness of the concept of value, thus forcing these hunter-gatherers to change their normal behaviour and engage themselves in specialised hunting of fur-bearing animals and red and roe deer, exploiting their antlers and skin far beyond their own needs. The increased contact did not, however, result in a transition towards full agrarian cultivation or husbandry practices for these hunter-gatherers of the Late Ertebølle Culture. The interaction did, on the other hand, probably have an impact on their mindset, as they became aware of concepts such as the value of things, thus paving the way for becoming increasingly complex hunter-gatherers, although evidence of major inequality and hierarchical organisations remains difficult to detect in the archaeological material. But this example and hypothesis of fur for shoe-last axes involves so many perspectives that it invites more detailed and further investigations in the future.

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Axes make the man. The social and economic value of axe blades in the Neolithic

Florian Klimscha

Zusammenfassung

Beile machen Leute. Der soziale und ökonomische Wert neolithischer Beilklingen

Der Beitrag untersucht anhand von Fallstudien in Mittel- und Südosteuropa die Herstellung und Nutzung neolithischer Steinbeilklingen und -axtköpfe. Es wird argumentiert, dass Beile und Äxte von großer Bedeutung in frühagrarischen Gesellschaften waren und ein hoher Aufwand bei ihrer Herstellung betrieben wurde. Anhand von Reduktionssequenzen lässt sich aufzeigen, dass auch kleine Fragmente noch zu neuen Beilen recycelt wurden. Als Grund dafür wird der hohe Aufwand beim Schleifen vorgeschlagen. In Europa lassen sich mehrere großflächig verbreitete Designs unterscheiden, die mit Migrationen und Innovationsbündeln korrelieren. Die Bedeutung von Beilen im Neolithikum ist kaum zu überschätzen. Sie sind die neolithischen Artefakte par excellence.

Schlagwörter Steinbeile, Streitäxte, Prestigeobjekte, Reduktionssequenz, Innovationstransfer

Summary

This paper examines case studies in Central and South-Eastern Europe concerning the production and use of Neolithic stone axes (including adzes) and battleaxes. It is argued that both axes and battleaxes were of central importance for early agrarian societies who put great effort into their production. Reduction sequences of stone axes and battleaxes highlight that even small fragments were recycled into new tools, which is probably the result of the high amount of labour put into the polishing. Several axe designs in Europe correlate with migrations or innovation bundles. The importance of axes in the Neolithic period can hardly be overestimated. They are the Neolithic artefacts par excellence.

Keywords Stone axes, battle-axes, prestigious objects, reduction sequence, diffusion of innovations

Introduction: What is an axe?

Axes are a key element of human societies. They are the most important tools in many Neolithic economies and a major break in the development of tool technology. Since the Lower Palaeolithic, humans have been making tools that enhance the natural functions of the human body (Léroi-Gourhan 1988), but axes are the first tools that use a long haft to give the human body the necessary leverage to chop down heavy objects (cf. Jankuhn 1978; Finsterbusch/Thiele 1987). We mainly think of trees, but it has been suggested that hunting and killing reindeer was also one of the primary functions of early axes (Tromnau 1984). The oldest tools identified for this task are the Lyngby axes of the Late Palaeolithic (Jensen 1991).

German-speaking scholars separate axes into *Beile* and *Äxte*: a distinction that cannot be translated into English as well as many other languages, where the appropriate terms are non-existant[1]. The classification is based on the occurrence of a shaft-hole and in some cases ignores the possibility that small axe blades can be hafted in an antler sleeve, thereby making a *Beil* factually an *Axt*. Nevertheless, the distinction is of great help for a principal division of the finds from the point of view of hafting, and this can roughly be translated into functional differences, too.

Especially the so-called battleaxes are noteworthy in this regard, and they strengthen the point that there is not only morphological but also functional evidence for this grouping. Anglophone studies, on the other hand, differentiate between *axes* and *adzes* on a functional level (cf. Hahn 1991, 165–166). However, this differentiation is difficult to uphold with regard to the artefacts preserved in the archaeological record. While there have been attempts to divide functional groups on the microscopic level, these can only give us a picture of the latest reduction stage of a tool; by their very nature, they disregard the different usages lithic artefacts have during their lifetime. What is ultimately needed is a body of case studies that combines both approaches and are based on a large enough sample. Otherwise, we risk taking taphonomic consequences for prehistoric realities whenever, for instance, only small reduction stages are available and it is not taken into account that these artefacts also had uses when they were larger. In this paper, I will use the word *axe* for all these artefacts. There is still too much work to be done to dogmatically use one set of nomenclature for an object group so large at the current state of research.

1 Winiger 1991 correctly stresses that the terminology is actually flawed since, in nearly all cases, it is just the axe *blades* that are preserved and summed up under the term *axes*.

The emergence of axes and axe ideologies

Axes were invented in the Palaeolithic[2]. Possibly they were even invented several times on the globe since, at the moment, it is difficult to find a connection between early axes from Europe, Eastern Asia, and the Americas (Jankuhn 1978). I cannot deal with this large body completely and will refer to case studies mostly from Northern Central[3] and South-Eastern Europe[4] in the following. From the Mesolithic onwards, lithic axe blades that were combined with a shaft made from organic material were a major innovation. It is yet unclear where this new technology originated. In Europe, we see it first in the Maglemose (Duvensee) Culture of the Mesolithic (Troels-Smith 1937), but very early axes in the 7th millennium are also known from South-Eastern Europe (Klimscha 2014). Thus, from a chronological point of view, it would indeed be possible to establish a connection between the North European Plain and the Balkans.

The concept of an axe is indeed known before the arrival of Neolithic settlers, and perforated antler axes are seen by most scholars as a Mesolithic invention that was used for chopping wood[5]. In some cases they were decorated to such a degree that it is difficult not to imagine a distinguishing or ritual function for these objects (Mührenberg 2022).

Be that as it may, axe-like tools have a long tradition, and even multi-part axes with blades made of flint or ground stone might have emerged in several places, but their find numbers explode in Neolithic times. This is especially true for Central Europe, where literally thousands of stone axes with a D-shaped section – the so-called shoe-last celts – can be attributed to the first farmers of the Linear Pottery Culture (LBK) and their extensive clearing of forests (Fig. 1)[6]. In contrast to Palaeolithic and Mesolithic axe use, the impact of the LBK can be seen with pollen diagrams[7], and it possibly even had an effect on the global climate by being related to a rise in CO_2 around 5000 BC (Ruddiman 2016). Further research is required to confirm this scenario, but from the archaeological point of view the arrival of the LBK is a dramatic break. Houses that are larger than some of the hunter/gatherer sites we know from previous periods, new technologies, domestic animals and plants, and a new ideology transform Central Europe permanently. This can be generally claimed for many early farming cultures spreading in Western Eurasia in the 6th and 5th millennium, and the change is strongly connected with axes. Axes were used to chop down trees to clear forest for villages and farm land. They were used to build houses and butcher animals. And, as we know from the gruesome massacre finds, they were also used as a weapon in times of war (Wahl/König 1987).

Maybe it is therefore no surprise that axes quickly became an essential part of what we can reconstruct of the rituals of early farmers. Axe hoards start with the LBK, but it is especially during the times following the LBK that the phenomenon reached several peaks (Müller/Hoffmann 2022). The first one can be attributed to the *Stichbandkeramik* and Rössen Cultures, as is well represented by finds such as those from Schladen, Wolfenbüttel district (Fig. 2). These finds consist of both axes and massive perforated axes, and they have recently been discussed in their superregional context (Müller/Schirren 2022). It is especially striking that the shaft-holes are rather small with regard to the size and weight of the axes and that the cutting edges show barely anything that can be interpreted as use wear: These artefacts were far too large to be used. They were made to be deposited. Not all Neolithic hoards contain axes that big; there are also those which include heavily worn and smaller pieces. Nevertheless, it is clear that axes are known from ritual contexts right from the beginning of the Neolithisation, and these rituals continue for at least 500 years. The underlying beliefs were shared over large parts of Europe (Müller/Schirren 2022, 143 Fig. 5). A slightly offset find from the Danish islands is a key argument for the presence of farmers on Mesolithic territory because axe hoards are simply not known from Mesolithic hunter-gatherers. Hoards, and especially those with axes, are an ideological innovation bound to farming.

The number of axes in use

So how many axes are there in a Neolithic household and how were they used in the everyday life of farmers? Sadly, the poor preservation of floors from the Early and Middle Neolithic in Central Europe makes it hard to answer these questions. It is therefore necessary to shift the focus to the tell sites of the Copper Age in the Balkans, which are roughly contemporary with the Middle Neolithic (Govedarica 2016), and to the ongoing excavations of the »Magura Gorgana« site in Pietrele, Giurgiu district (Romania), and its surroundings[8]. The multi-layered tell settlements provide us with precisely the taphonomic conditions that are necessary to go deeper into the meaning of Neolithic axes. As an aside, one could also include the circumalpine lake dwellings, which I will only omit due to a lack of space. In Pietrele, several buildings, often destroyed by fire catastrophes, were preserved with most of the artefacts used by the inhabitants. This allows an insight into the numbers of axes used at the same time by a single household (Klimscha 2016, 120–123). It is not only possible to see that complete pieces were only found inside houses (Fig. 3–4), but also that there seems to be a significant difference between houses on the tell itself, but also between houses on the tell and those in the surrounding settlement, where usually much fewer pieces are found in the houses. This has been interpreted as a difference of rank, but taphonomic factors and possibly specialisation could also have influenced the picture (Klimscha 2011; Klimscha 2020). A single house in Pietrele can result in the same amount of axes as an LBK settlement (Kahn 2007). Does this mean that axes were not used as often in the LBK? Or that they were shared between the inhabitants in some form of *Ur*-communism? I do not think so, but would explain the differences by

2 Cf. the so-called Lyngby axes, e.g., Schwantes 1939, 84 Abb. 82.
3 The best overview is still Brandt 1967.
4 Cf. Klimscha 2016 with further literature.
5 However, see Klassen 2000 with a possible deduction of Mesolithic antler axes from South-Eastern Europe.
6 Cf. Hofmann 2022 with further literature.
7 Kirleis 2022 with a recent overview.
8 For the axes, see Klimscha 2016. A good overview of the excavation can be found in Hansen 2015.

Fig. 1 Typical shoe-last celt and two smaller stone adzes from an LBK settlement at Rössing, Hildesheim district. Length 30.6 cm.

Abb. 1 *Typischer Schuhleistenkeil und zwei kleinere Steinbeile einer linienbandkeramischen Siedlung bei Rössing, Lkr. Hildesheim. Länge 30,6 cm.*

Fig. 2a–c Hoard find from Schladen, Wolfenbüttel district. Lengths of the artefacts: a 35.5 cm; b 23.6 cm; c 16.9 cm.

Abb. 2a–c *Hortfund von Schladen, Lkr. Wolfenbüttel. Länge der Artefakte: a 35,5 cm; b 23,6 cm; c 16,9 cm.*

Fig. 3a–b Finds of axes from outside the houses at Pietrele, Giurgiu district (Romania). a Trench B, finds from the gaps between the houses; left fragments, right complete axes; b Trench F, finds from the upper, burnt Central House; left complete axes, right fragment. While in the gaps between the houses, only very small axes survive among various fragments of axes, within the houses the complete set of large, medium, and small axes is regulary found, but rarely fragments.

Abb. 3a–b *Beilfunde, die innerhalb und außerhalb der Häuser bei Pietrele, Kr. Giurgiu (Rumänien), gefunden wurden. a Fläche B, Gassen zwischen den Häusern; links Fragmente, rechts vollständige Beile; b Fläche F, Funde aus dem oberen, verbrannten Zentralhaus; links vollständige Beile, rechts Fragment. Während zwischen den Häusern nur sehr kleine Beilklingen und ansonsten nicht umgearbeitete Fragmente gefunden werden, enthalten Häuser regelmäßig ein komplettes Set aus großen, mittleren sowie kleinen Beilklingen und nur sehr selten einzelne Fragmente.*

taphonomic processes. In the lake dwellings, the numbers of axes per house are similar to Pietrele, so I would argue that this picture is no exception but rather the reality for most Neolithic cultures of the 6th and 5th millennium. This is also the time when the Danubian Neolithic cultures reach their maximum expansion. From the point of view of axes, a major break is the rise of the South-East European Copper Age. It leads to a new axe design. Four-sided types influenced by the emergence of copper axes supersede roundish to D-shaped types (Fig. 5). The latter dominate axe designs for the next few thousand years and are only replaced in the Bronze Age with socketed axes.

The life of an axe

Even though axes are not living beings, they do have a life (cf. *in extenso* Klimscha 2016, 79–104). This can best be understood by looking at the cutting edge and lengths of flint axes. The cutting edges are the most fragile part of an axe and break most often. The cutting edge thereby shifts from a rounded shape to a diagonal shape before it becomes triangular (Fig. 6). At this point it cannot be repaired anymore and the axe is shortened. And if a certain length cannot be reached anymore, what is left can be recycled as a core, made into a small tool, or the triangular cutting edge is blunted and used as a hammer (Fig. 7–11).

Similar processes can be identified also for the ground stone axes. It is possible to identify regular working steps here (Fig. 12–13). And the identification of house-specific repair traces on ground stone axes suggests that the axes were indeed owned by a household (Klimscha 2010). Even small fragments were still reworked into new axes, which is the best explanation for the huge typological variety of ground stone axes. The reason why the fragments can still be grouped into shapes is a simple functional principle,

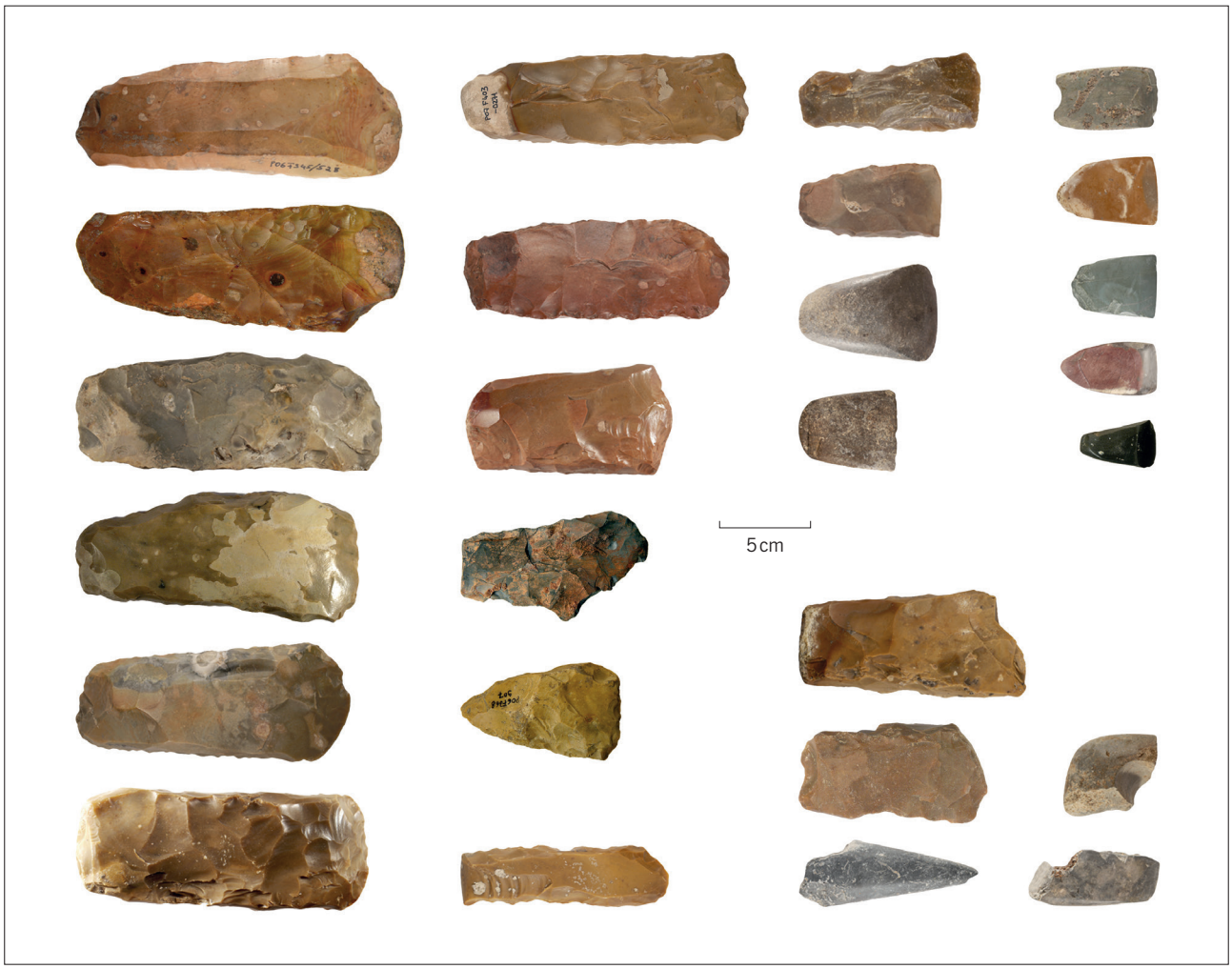

Fig. 4 Finds of axes from within a house at Pietrele, Giurgiu district (Romania), trench F, finds from the lower, burnt Central House.

Abb. 4 *Beilfunde aus dem Inneren eines Hauses bei Pietrele, Kr. Giurgiu (Rumänien), Fläche F, Funde aus dem oberen, verbrannten Zentralhaus.*

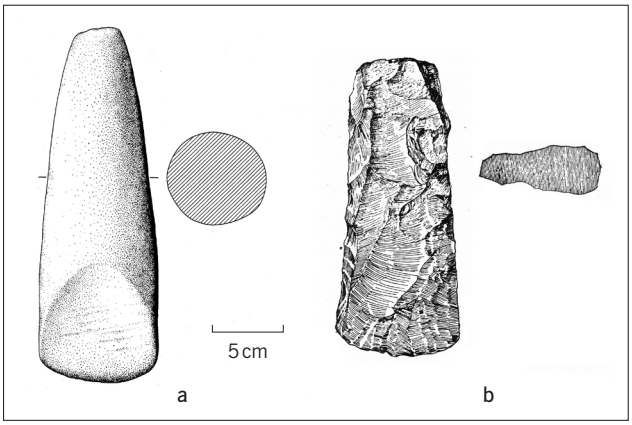

Fig. 5a–b Comparison of the axe design from the Danubian Neolithic (a, from Ovčarovo-Gorata, Targovishte Province [Bulgaria]) and the Copper Age (b, from Ruse [Bulgaria]). The former seems to be influenced by antler axes, whereas the latter is clearly derived from metal axes.

Abb. 5a–b *Vergleich der Beilformen aus dem donauländischen Neolithikum (a, aus Ovčarovo-Gorata, Oblast Targowischte [Bulgarien]) und aus der Kupferzeit (b, aus Russe [Bulgarien]). Ersteres scheint von Geweihäxten beeinflusst zu sein, wohingegen sich Letzteres eindeutig von Metallbeilen ableitet.*

Fig. 6 Schematical development of the shape of a cutting edge of an axe as demonstrated by the finds of silex axes from Pietrele, Giurgiu district (Romania); no scale.

Abb. 6 *Schematische Entwicklung der Klingenform von Beilen anhand von Silexbeilen aus Pietrele, Kr. Giurgiu (Rumänien); o. M.*

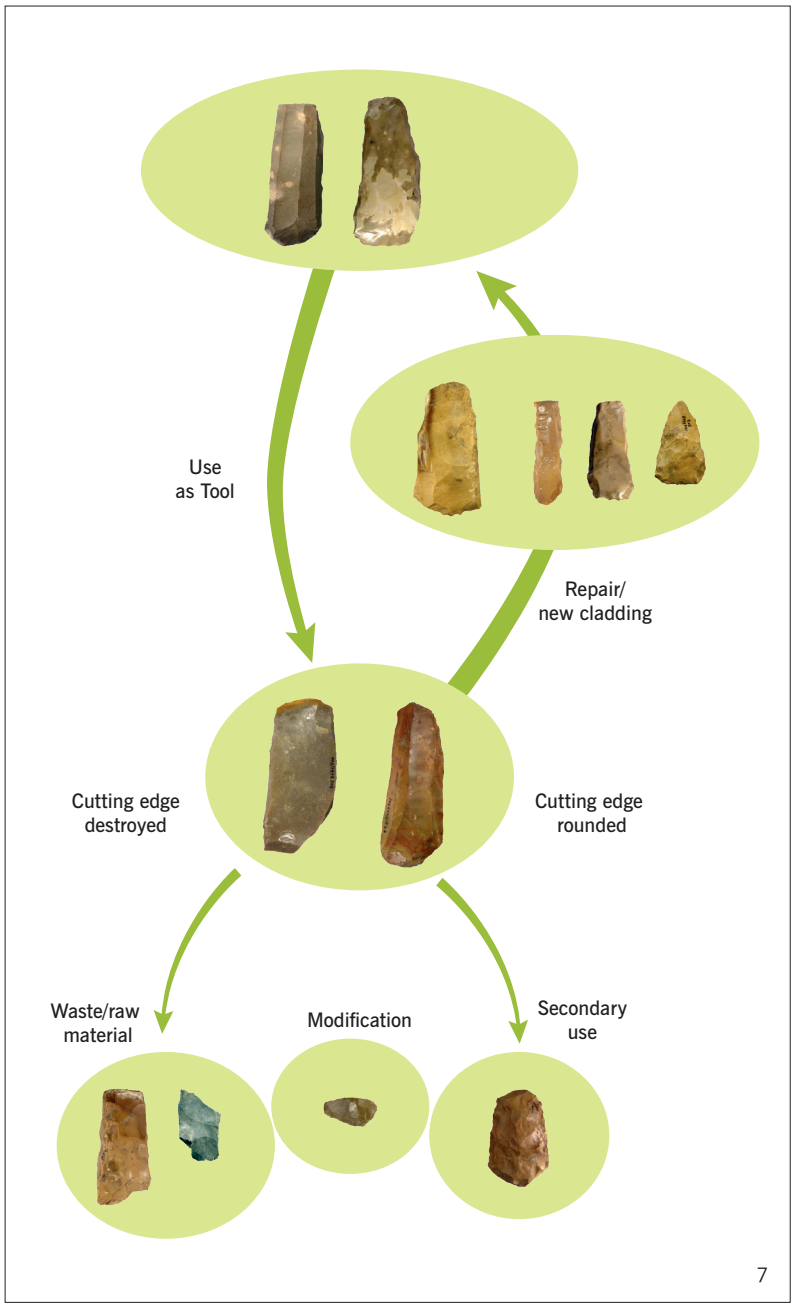

Fig. 7 The reduction sequence of flint axes at Pietrele, Giurgiu district (Romania).

Abb. 7 *Reduktionssequenz von Feuersteinbeilen aus Pietrele, Kr. Giurgiu (Rumänien).*

Fig. 8 Sequence of reduced flint axe blades from Pietrele, Giurgiu district (Romania). A damaged axe was further reduced with every repair until it was too small to be hafted and thus recycled as a core.

Abb. 8 *Abfolge von reduzierten Feuersteinbeilen aus Pietrele, Kr. Giurgiu (Rumänien). Beschädigte Beile wurden mit jeder Reparatur kleiner, bis sie zu klein waren, um geschäftet zu werden, und als Kern weiterverwendet wurden.*

namely the hafting: The axes are reworked as long as they fit into an antler sleeve (Fig. 14); and if they do not, they can still be used as polishers or rubbers (Fig. 15). So why did prehistoric communities do this? I will argue that the time spent working and polishing an axe blade was considerable, and the axe therefore was a valued possession. From experimental studies it is known that it was especially the polishing that took enormous time (Hansen/Madsen 1983; Madsen 1984), and therefore this time was saved as long as the polished fragments of larger axes were large enough to fit in a handle.

This is a key result as it implies that even though the archaeological record is full of axes – and we know from the excavation from quarries that many more must have existed (Schyle 2010) – the material was considered valuable enough to recycle as long as possible. This parsimonious attitude stands in stark contrast to the amount of axes deposited in hoards (Rech 1979) or the amount of labour and time spent for the construction of some of the really large specimens such as the find from Brunswick-Geitelde, which might be related to a nearby Michelsberg enclosure (Fig 16).

I cannot go into detail for the reduction sequences of battleaxes in this paper, but they follow the basic principles (Klimscha 2016, 91–95). Recent studies have interpreted the breaking of these axes as part of a ritual (inter alia Grisse 2006), but the reduction sequences rather show that axe morphology is heavily determined by recycling broken cutting-edge fragments into smaller axes. The possibility to highlight regular stages in this process as well as the much higher find frequency of butt fragments than cutting-edge fragments (Klimscha 2016, 91) if anything demonstrates that battleaxes frequently broke when used, and the bigger part, namely the cutting edge, was recycled into a smaller

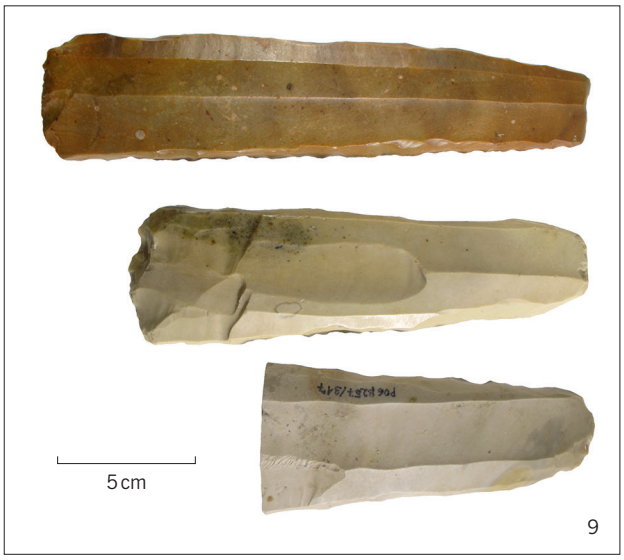

Fig. 9 Flint axes with negatives from blade production from Pietrele, Giurgiu district (Romania). Flint axes frequently broke around the cutting edge; the old and damaged one could be removed and a new cutting edge could be fashioned. This resulted in a shortening of the axe blade.

Abb. 9 *Feuersteinbeile mit den Negativen von Klingenabschlägen aus Pietrele, Kr. Giurgiu (Rumänien). Feuersteinbeile brachen oft an der Schnittkante. War diese alt und beschädigt, konnte sie entfernt und eine neue Schnittkante geschlagen werden. Dadurch verkürzte sich die Beilklinge.*

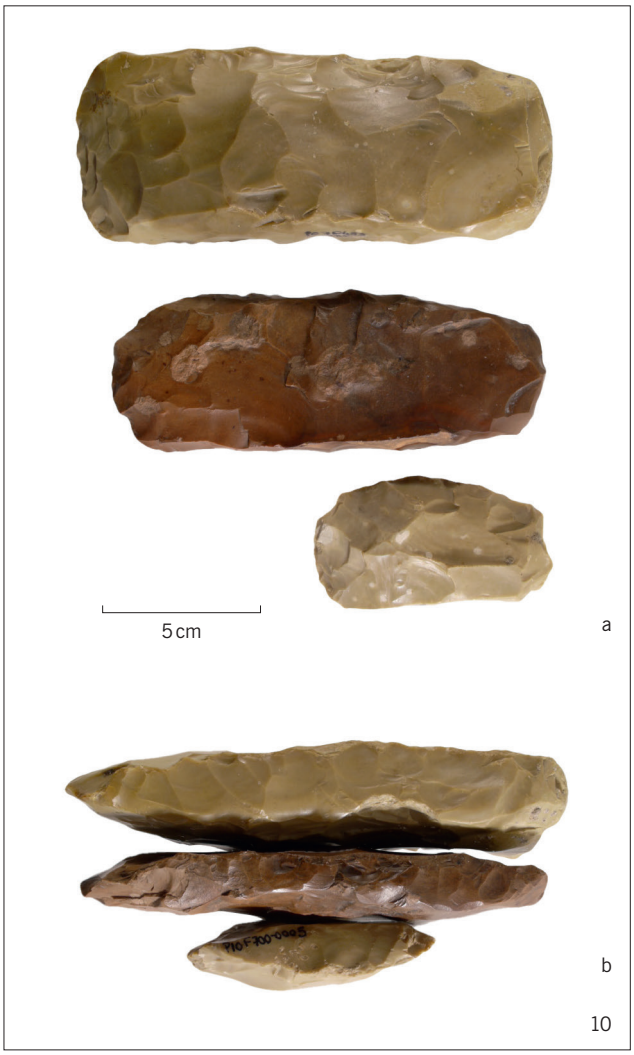

Fig. 10a–b Flint axes of different lengths (a) from Pietrele, Giurgiu district (Romania) vary only insignificantly in their thickness (b). This is the result of the frequent shortening of axes in the recycling process. Damaged axes were repaired with the aim of minimising material loss.

Abb. 10a–b *Feuersteinbeile unterschiedlicher Länge (a) aus Pietrele, Kr. Giurgiu (Rumänien) variieren kaum in ihrer Dicke (b). Dies ist das Resultat wiederholter Beilkürzungen als Teil des Recyclingprozesses. Beschädigte Beile wurden mit dem Ziel repariert, den Materialverlust zu minimieren.*

Fig. 11a–b Two examples of flint axes from Pietrele, Giurgiu district (Romania). The axes vary considerably in their overall size, especially in their length (a 14.4 cm, b 9.0 cm). However, the thickness is similar (a 2.3 cm, b 1.9 cm), and often smaller fragments show traces of surface retouch only on one side (the undamaged one), hinting at a former stage in which they were parts of larger axe blades.

Abb. 11a–b *Zwei Feuersteinbeile aus Pietrele, Kr. Giurgiu (Rumänien). Sie unterscheiden sich stark in ihrer Gesamtgröße, vor allem in ihrer Länge (a 14,4 cm, b 9,0 cm). In ihrer Dicke ähneln sie sich jedoch (a 2,3 cm, b 1,9 cm), und kleinere Fragmente sind oft nur auf einer Seite (der unbeschädigten) oberflächlich retouchiert. Dies weist darauf hin, dass sie einmal Teil größerer Beilklingen waren.*

Fig. 12a–c Reduced stages of ground stone axes at Pietrele, Giurgiu district (Romania). a Different breaks and damages can occur on larger axes and these are the basic forms for the creation of new tools, as is shown here; b The most frequent damages occur at the cutting edge, and during a repair this creates »diagonal« cutting edges, as shown here; c Butt-fragments can be recycled into smaller axes, often showing a very steep cutting edge, as illustrated here.

Abb. 12a–c *Reduzierte Stadien geschliffener Steinbeile aus Pietrele, Kr. Giurgiu (Rumänien). a Die unterschiedlichen Brüche und Beschädigungen, die an größeren Beilen vorkommen, bilden die Grundlage der Schaffung neuer Werkzeuge, wie hier zu sehen; b Beschädigungen treten meist an der Schneide auf. Bei der Reparatur entsteht eine »diagonale« Schneide, wie hier zu sehen; c Nackenfragmente können zu kleineren Beilen mit oft sehr steiler Schneide recycelt werden.*

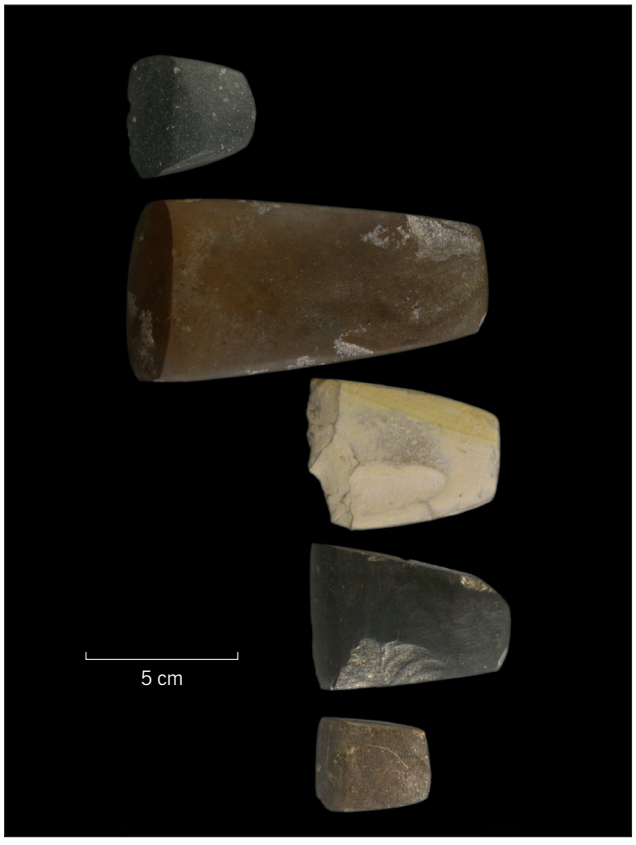

Fig. 13 Recycling of the different parts of a medium-sized ground stone axe exemplified with finds from Pietrele, Giurgiu district (Romania).

Abb. 13 *Recycling der verschiedenen Teile eines mittelgroßen geschliffenen Steinbeils am Beispiel von Funden aus Pietrele, Kr. Giurgiu (Rumänien).*

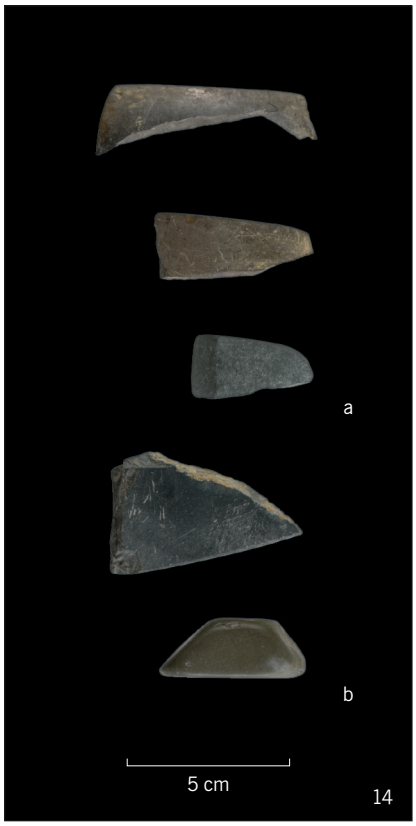

Fig. 14a–b Ground stone-axe fragments from Pietrele, Giurgiu district (Romania) that cannot be reduced further and examples of the tool types they were worked into. a Lateral fragments can sometimes be worked into chisel-like tools; b Fragments from an already damaged or shattered axe blade can be turned into polishers.

Abb. 14a–b *Fragmente geschliffener Steinbeile aus Pietrele, Kr. Giurgiu (Rumänien), die nicht weiter reduziert werden können, und Beispiele der Werkzeugtypen, zu denen sie umgearbeitet wurden. a Laterale Stücke können manchmal zu meißelartigen Werkzeugen verarbeitet werden; b Fragmente einer bereits beschädigten oder zertrümmerten Beilklinge können zu Glättern verarbeitet werden.*

Fig. 15 Ground stone axes reduced to the minimum width and thickness necessary to fit into an antler sleeve. Examples from Pietrele, Giurgiu district (Romania).

Abb. 15 *Geschliffene Steinbeile, die auf die bei der Geweihschäftung kleinstmögliche Breite und Dicke reduziert wurden. Die Beispiele stammen aus Pietrele, Kr. Giurgiu (Rumänien).*

Fig. 16 Jadeite axe from Brunswick-Geitelde. Lenght 45 cm.

Abb. 16 *Jadeit-Beil aus Braunschweig-Geitelde. Länge 45 cm.*

weapon (Fig. 17). If we refer to what is currently known about the context of complete specimens of this type, namely burials of the highest quality, we may refer to the presence of high-status warriors from concentrations of axe fragments. And probably also to fighting.

Pietrele is associated with the Copper Age cultures of the KGKVI complex, which is best known for the spectacular wealth of the burial ground of Varna at the Bulgarian Black Sea coast (Fol/Lichardus 1988; Krauß et al. 2014; Leusch et al. 2014). It might be worth reconsidering that graves identified as very rich in Varna specifically, but also in the Copper Age in general, usually comprise copper (Schubert 1965; cf. also Boroffka 2009) and stone battleaxes, copper flat axes, and so-called *super blades*. The latter can be described as flint blades produced by lever technique that reach lengths of up to 30 cm and in some cases even more

Fig. 17a–b Reduced stages of battleaxes at Pietrele, Giurgiu district (Romania). a Axes frequently break at their shaft-hole. The butt is discarded (or recycled into unidentified fragments), whereas the cutting-edge fragment is drilled again and reworked into another battleaxe; b very small fragments can still be turned into flat axes (»adzes«).

Abb. 17a–b *Reduzierte Streitäxte von Pietrele, Kr. Giurgiu (Rumänien). a Axtköpfe brechen häufig am Schaftloch. Das Nackenstück wird weggeworfen (oder zu nicht identifizierbaren Fragmenten umgearbeitet), wohingegen die Schneide erneut durchbohrt wird und zu einer neuen Streitaxt verarbeitet wird; b sehr kleine Fragmente können noch in Flachbeile (Dechsel) umgewandelt werden.*

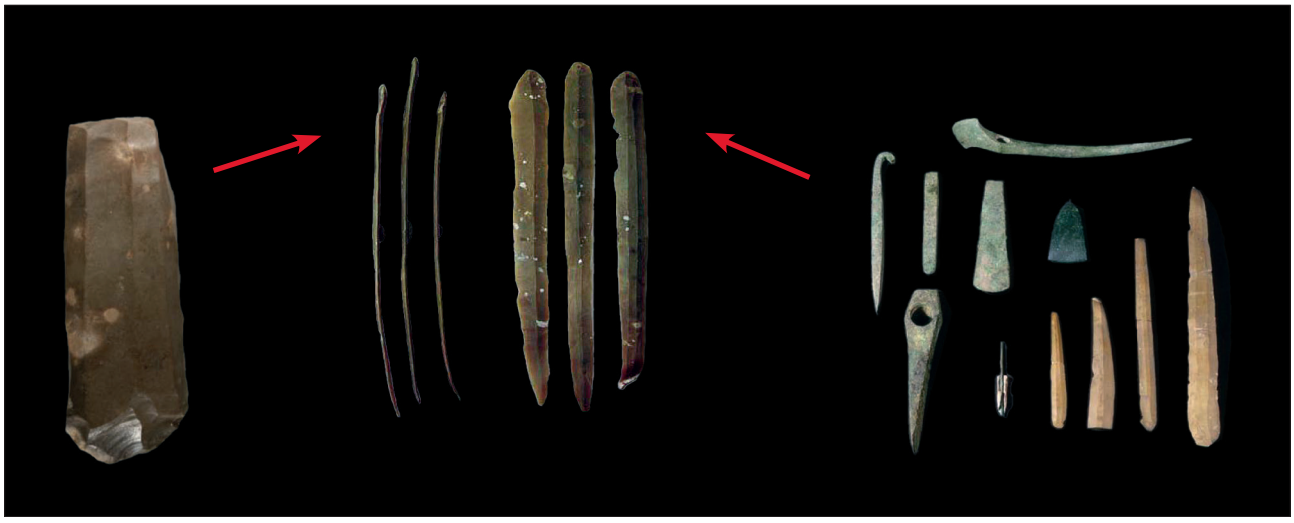

Fig. 18 Relations of super blades and flint axes within the same *chaîne opératoire* as exemplified with finds from Pietrele, Giurgiu district (Romania), and Varna (Bulgaria).

Abb. 18 *Beziehung zwischen »Superklingen« und Feuersteinbeilen innerhalb einer* chaîne opératoire *am Beispiel von Funden aus Pietrele, Kr. Giurgiu (Rumänien), und Varna (Bulgarien).*

(Manolakakis 2002). These super blades share a *chaîne opératoire* with the silex axes prominent in Copper Age settlements of the Gumelniţa Culture on the Lower Danube (Fig. 18; Klimscha 2007; Klimscha 2017). And thus the whole set of presumedly male status symbols is centred upon axes: axes as tools, axes as weapons, and axes as symbols of access to copper and high-quality flint. This can to some degree also be shown for other burial grounds, though many are not as richly furnished as Varna. In Varna, burial 43, another very interesting detail needs to pointed out: The grave is one of the richest on the burial ground and includes all the aforementioned status symbols. One point-butted axe deserves special mention. It is prominently placed between the buried individual's legs, and it is no simple ground stone axe, but has been identified as an Alpine greenstone rock (Fig. 19). This is no single case, and by now a considerable amount of Jadeitite axes in south-eastern Europe makes clear to us that the axe in Varna, grave 43, was no coincidence (Pétrequin et al. 2012) but rather the result of participation in trans-European networks exchanging prestigious axes. The famous stratigraphy of the tell site Karanovo also highlights this connection, and the point-butted axe bridging Karanovo V and VI has been identified as an alpine greenstone axe, too (Fig. 20; Böhm/de Laet 1961, Supplement).

These alpine greenstone, foremost Jadeitite axes occur roughly at the same time as the earliest copper axes in the Balkans, and they represent another model of social distinction that is very prominent in Brittany in North-west France (Thirault 2004). I refer to the famous burials in the Morbi-

Fig. 19 Varna (Bulgaria). Grave 43 with the jadeitite axe marked.

Abb. 19 *Varna (Bulgarien). Grab 43 mit markiertem Jadeitbeil.*

Fig. 20 Stratigraphy of Tell Karanovo, Sliven province (Bulgaria), with the jadeitite axe marked on the transition from Karanovo V to VI.

Abb. 20 *Stratigrafie von Tell Karanovo, Obl. Sliwen (Bulgarien), mit markiertem Jadeitbeil am Übergang von Karanovo V zu VI.*

Fig. 21 Jadeite axes from the tumulus of Turmiac, Arzon, Brittany (France).

Abb. 21 *Jadeitbeile aus dem Tumulus von Turmiac, Arzon, Bretagne (Frankreich).*

han. A.-M. and P. Pétrequin, together with S. Cassen and a large international team, have studied the axes found in these burials in detail (Pétrequin et al. 2012a). They derive from the Ligurian Alps and are used to furnish burials of unprecedented wealth (e.g., Fig. 21; Vigier 2022). The inventories in the graves find their only analogies in contemporary hoards, usually interpreted as gifts for supernatural beings. Were the buried persons therefore sharing the same status as the addressees of the hoards? Possibly something like divine rulers?

The design of the Jadeitite axes with a pointed butt and a two-sided section becomes very influential in the following centuries. During the 5th millennium, the point-butted axe design spreads east and becomes integrated into the Michelsberg Culture. In the Low Countries, Northern and North-western Germany, and Southern Scandinavia, point-butted axes form part of the earliest Neolithic[9], but they are also appropriated in the Alpine region (Pétrequin et al. 2010). They likewise influence the design of some of the earliest copper axes from Lower Saxony to Thuringia (Pétrequin et al. 2008). Point-butted, triangular copper axes of the type found in Hertingshausen, Kassel district, seem to be a unique appropriation of metallurgical knowledge within the context of the Michelsberg Culture (Fig. 22). I stress this fact because usually Michelsberg is characterised as rather poor when it comes to copper objects (Jeunesse 2010).

The question how much copper was available outside of Southeastern Europe and the Carpathian Basin has been hotly debated (cf. Kienlin 2008). To summarise the recent research, one can say that there was nothing comparable to the Copper Age outside the Balkans and the Carpathian Basin, and therefore phase names in Central Europe still refer to the 5th and 4th millennium as Neolithic and not Chalcolithic. As we have seen, however, there is a record of Michelsberg metal finds, and possibly the lack of burials fools us in this regard (Jeunesse 2010).

9 Montelius 1874 with the original typology.

Fig. 22 Point-butted copper axe imitating a Jadeite axe, from Hertinghausen, Kassel district, assumed to belong to the Michelsberg Culture. Length 12.6 cm.

Abb. 22 *Kupferbeil mit spitzzulaufendem Nacken, das ein Jadeitbeil imitiert, aus Hertinghausen, Lkr. Kassel. Der Fund wird, der Michelsberger Kultur zugeschrieben. Länge 12,6 cm.*

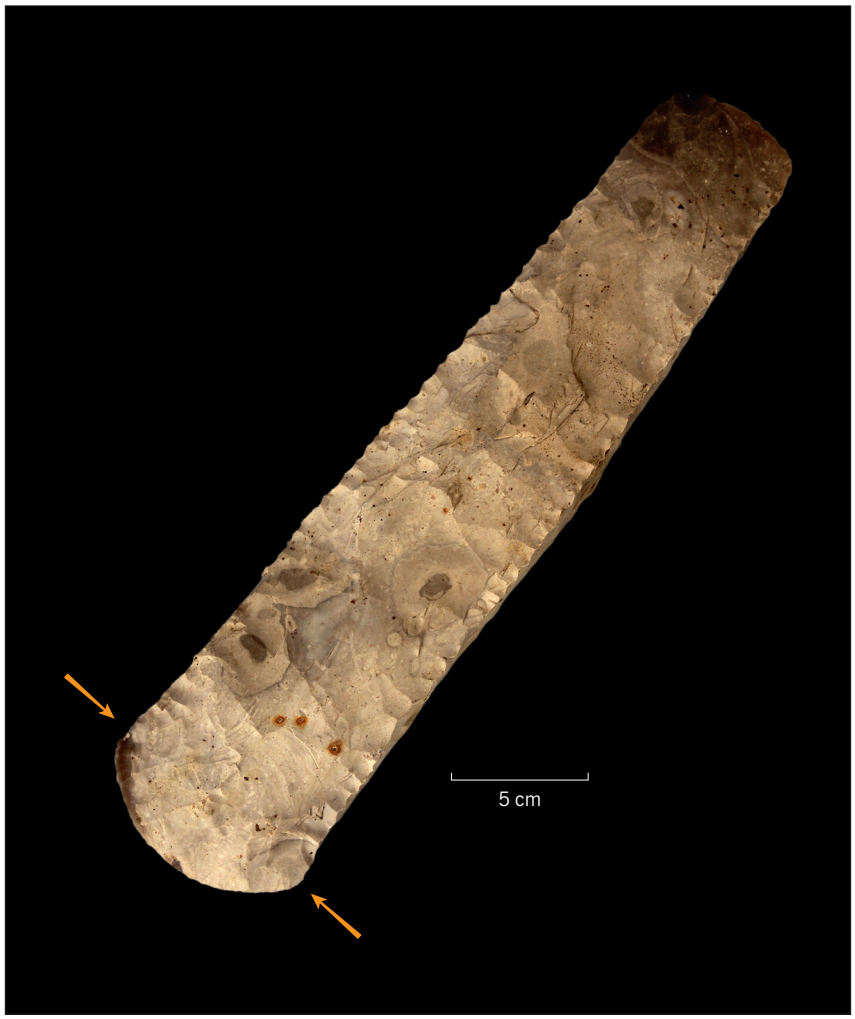

Fig. 23 Thin-butted flint axe from Lübeck-Gneversdorf with a cutting edge imitating a copper axe. Length 35 cm. Arrows: extended edge.

Abb. 23 *Dünnnackiges Feuersteinbeil aus Lübeck-Gneversdorf mit einer Schneide, die ein Kupferbeil imitiert. Länge 35 cm. Pfeile: ausgezogene Scheide.*

When we go to the 4th millennium, the Funnel Beaker societies in the North European Plain are another enigmatic copperless Neolithic. Recent finds in Denmark and Northern Poland, however, were able to identify crucibles and have thus changed the picture dramatically (Gebauer/Sørensen 2022). Suddenly the copper types found in the famous hoards of Bygholm, Mid Jutland (Denmark), and Riesebusch, Ostholstein district (Germany; Klimscha/Neumann 2022; Freudenberg/Glaser 2022; cf. also Neumann/Ostrowski 2022) that are specific to the North become plausible as remelted and locally cast[10]. And while the amount of copper in the Funnelbeaker Culture is still low compared to the Balkans, we have further evidence from Megalithic burials in Lower Saxony (Schlicht 1973) in addition to the flint axes with cutting edges imitating contemporary copper axes (Fig. 23). This argument is stronger than it might seem at first glance, since the cutting edge of such a type will easily break and requires the removal of considerable amounts of raw material when produced on a flint axe; associating the axe with copper specimens is thus an intentional and work-intensive step (Klimscha 2016, 206–212).

Flint axes of the Funnelbeaker Culture are found in tens of thousands (Bastian 1954; Nielsen 1977). This paper cannot go into detail here, and therefore only one specific aspect of the Funnelbeaker Culture axes will be highlighted: the widely shared idea of hoarding very similar axes of the thin-butted type. A map produced by M. Müller shows the distribution that connects the Low Countries with Western Ukraine (Müller/Hoffmann 2022, Fig. 5). Here, the establishment of a koine of shared prestigious axes and shared rituals in which these axes are prominently featured can be seen.

This has consequences. The most dramatic change within the Neolithic is the use of cattle teams to pull wagons and ploughs from around 4000 BC onwards[11]. One of the earliest finds, the famous hoard from Bytyń, voi. Greater Poland (Poland; Pieczynski 1985), connects the Funnelbeaker Culture axe ideology with the symbol of the new age: two yoked cattle (Fig. 24). When seen in a larger picture, the Bytyń hoard links the earliest evidence for cattle-drawn vehicles in the Tripolye and Majkop Cultures with the early Funnelbeaker Cultures of the North, where we can identify wagons from at least the Fuchsberg stage onwards (Fig. 25;

10 See Klassen 2000 for the original thesis.

11 Klimscha 2018, 2021; cf. also Fansa/Burmeister 2004 and the papers therein.

Fig. 24 Hoard from Bytyń, Greater Poland Voivodeship (Poland). Apart from three copper axes, a yoked cattle team (which might belong to a wagon model) was included.

Abb. 24 *Im Hortfund von Bytyń, Woi. Großpolen (Polen), waren neben drei Kupferbeilen zwei Rinderplastiken, die unter einem Joch an ein nicht mehr erhaltenes Fahrzeug (vermutlich ein Wagen) angeschirrt waren.*

Fig. 25 Distribution of early evidence of wheeled vehicles before c. 3500 BC. a–c copper wagon models (yoked cattle pairs); 1–15 other evidence.

Abb. 25 Verbreitungskarte von frühen Nachweisen von Wagen mit Rädern, ca. 3500 v. Chr. a–c kupferne Wagenmodelle (gejochte Rinderpaare); 1–15 andere Belege.

Zich 1993). The spread of the wagon is no direct imitation of Pontic types; rather, technical details – for instance, the wheel construction – clearly show that only a template was spread and then built with locally available resources (Matuschik 2005). In my view, we can see areas such as the aforementioned flint axe koine as the medium in which the necessary knowledge spread to reinvent the wagon locally. This is further strengthened by another technology that travels to the north in the same way, namely, the cast copper battleaxes made from Arsenic copper (Fig. 26). These axes are known between the Black Sea and the North Sea. However, the finds are not spread evenly but rather are known from the Majkop area and Moldavia, and from North-West Germany, where they are found from Göttingen via the Middle Weser at Nienburg-Müsleringen to Osnabrück-Lüstringen (Neumann/Ostrowski 2022; cf. also Klimscha/Neumann 2022).

These networks – or rather spaces of tradition, as I have called them in another article (Klimscha 2017) – and the shared knowledge that can be identified by the specific axe designs endure. The design of Funnelbeaker and Single Grave Culture flint axes is so close that it is difficult or impossible to clearly identify single found pieces (Fig. 27). Thus, even population shifts did not necessarily change the axe production.

In conclusion, I want to shortly go back to where axe studies were left around twenty years ago[12]. We know from

12 Davis/Edmonds 2011 and the papers therein give a good overview.

a multitude of ethnographic sources that many Neolithic societies use axes as social markers, ritual objects, or prestigious items (Højlund 1978). We also know that at that time these axes were in some cases traded over vast distances in Europe (Jeunesse 2010). Meticulous studies of sites, milestone projects (Pétrequin et al. 2012a) like the research of jadeitite axes, and the availability of big data sets and spatial modelling have considerably enlarged our knowledge. We know that axes were an essential part of Neolithic communities and that their production was time-consuming so that single axes and parts thereof had a long period of usage consisting of many different stages (Klimscha 2016, 79–104). Axe designs can be attributed to specific cultural phenomena: the Danubian Neolithic, the southeast European Copper Age, or the Western European Neolithic do have different axes. These designs happen to correlate with new technologies such as metallurgy, traction, and the wheel, and I would argue that the exchange of axes via shared rituals or marriages might be the key to understanding the directed spread of technical innovation in prehistoric Europe.

Axes are omnipresent in Neolithic burials and offerings; axe design even has a priority when technology is innovated, as can be seen from the Michelsberg point-butted copper axes. Axes are essential tools, but also become a typical shape with Neolithic beads and pendants. When we have pictorial evidence in the Neolithic, it is often either axes or cattle teams. And some researchers even go so far as to refer to some menhirs and house shapes as resembling axes (Tilley/Thomas 1993). The social value of axes in the Neolithic can hardly be overestimated. One would certainly not go too far to call the European Neolithic the »Axe Age.«

Fig. 26 Battleaxe from Müsleringen, Nienburg district. Length 9.5 cm.

Abb. 26 *Streitaxt von Müsleringen, Lkr. Nienburg. Länge 9,5 cm.*

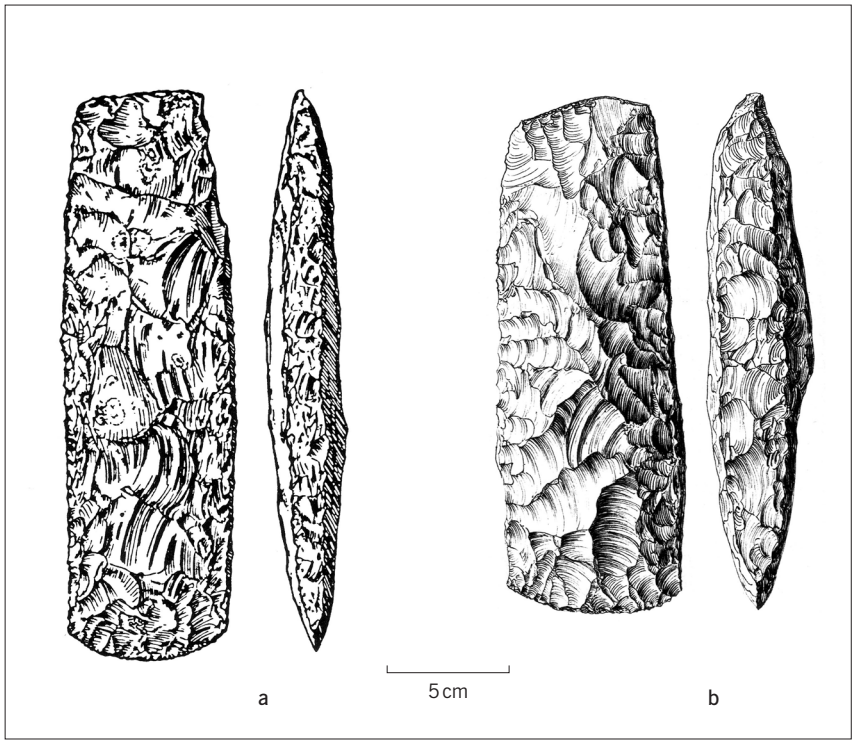

Fig. 27a–b The axe design of the Funnelbeaker Culture (a, find from Schwesing, Northern Frisia district) in comparison with that of the Single Grave Culture (b find from Rumohr, Rendsburg-Eckernförde district).

Abb. 27a–b *Vergleich zwischen dem Beildesign der Trichterbecherkultur (a Schwesing, Kr. Nordfriesland) und der Einzelgrabkultur (b Rumohr, Kr. Rendsburg-Eckernförde).*

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Neolithic axeheads from depositions in Middle and Northern Europe as representations of additional time investment

Michael Müller

Zusammenfassung

Axt- und Beilklingen aus neolithischen Deponierungen in Mittel- und Nordeuropa als Repräsentationen zusätzlich investierter Zeit

Die Trichterbecherkultur (TRB; 4100–2800 v. Chr.) zeichnet sich durch bemerkenswerte soziale Gemeinschaftsleistungen aus, darunter Megalithgräber, Grubenwerke und Depots. Unter den Deponierungen dominieren, neben jenen mit Bernsteinperlen, Keramikgefäßen, Kupferobjekten oder Knochen, vor allem solche mit Beilklingen aus Feuerstein. Die Beilklingen sind häufig zwischen 20 bis 50 cm lang und erforderten Expertise und hochwertigen Flint für ihre Herstellung. Archäologische Experimente zeigen, dass ihre Fertigung vermutlich mehrere Tage dauerte, wobei allein der Schleifprozess mehrere Dutzend Stunden in Anspruch nahm.

Die Gesamtzeit, die für die Rohstoffgewinnung, die Vorbereitung durch Spezialisten in Form erfahrener Flintschläger, und das stundenlange Schleifen zusammenkam, aber ebenso ihre nur sehr unzureichend rekonstruierbare Nutzungsphase, findet sich schließlich in den Horten akkumuliert. Obwohl die TRB die erste vollneolithische Kultur des nördlichen Europas darstellt, sind die sie auszeichnenden Phänomene lediglich eine Weiterentwicklung der früh- bis jungneolithischen Gruppen Mitteleuropas (Müller 2023). Während des dortigen Frühneolithikums (5500–4900 v. Chr.) und Mittelneolithikums (4900–4400 v. Chr.) wurden bereits übergroße Dechsel-, Axt- und Beilklingen aus Aktinolith-Hornblendeschiefer mit der Absicht niedergelegt, sie nie wieder zu bergen. Die Träger der jungneolithischen Michelsberger Kultur (4400–3500 v. Chr.) deponierten hingegen sehr große Beilklingen aus alpiner Jade bzw. alpinen Gesteinen genannten verschiedenen Materialien (Jadeitit, Omphacit, Eklogit). Die Rohstoffgewinnung und Herstellung der Beilklingen war, wie später in der Trichterbecherzeit, sehr aufwendig. Darüber hinaus wurden sie über einen langen Zeitraum in Tauschnetzwerken über weite Distanzen transportiert und regional modifiziert. Die präsentierten neolithischen Deponierungen lassen sich also, sowohl was ihren Herstellungsaufwand als auch die Biografie ihrer Objekte angeht, als Akkumulationen investierter Zeit interpretieren.

Schlagwörter Deponierungen, Neolithische Beilklingen, Beilklingenherstellung, Zeitinvestition, Trichterbecherkultur

Summary

The Funnel Beaker Culture (TRB; 4100–2800 BC) is characterised by remarkable collective achievements, including megalithic graves, causewayed enclosures, and hoards. Among the depositions, apart from those containing amber beads, ceramic vessels, copper objects, or bones, those featuring flint axeheads are predominant. These axeheads are frequently between 20 to 50 cm in length and required the expertise of specialists and high-quality flint for their production. Archaeological experiments reveal that their manufacturing lasted several net-hours, possibly spread across multiple days, with the laborious grinding process alone consuming several dozens of hours.

The cumulative time invested, encompassing resource acquisition, preparation by specialists in the form of experienced flint knappers, and hours of grinding, as well as their only very inadequately reconstructable utilisation phase, eventually accumulates in these hoards. While the TRB represents the first fully Neolithic culture of Northern Europe, its distinctive phenomena are essentially an elaboration of those observed in the Early to Younger Neolithic groups of Central Europe (Müller 2023). During the Early Neolithic (5500–4900 BC) and Middle Neolithic (4900–4400 BC) periods in that region, over-sized adze heads, shaft-hole axeheads, and axeheads of actinolite-hornblende schist (hereinafter referred to as AHS) were already being deposited, never to be retrieved. The bearers of the successive Younger Neolithic Michelsberg Culture (4400–3500 BC) deposited very large axeheads made from various materials, mostly jadeitite, eclogite and omphacitite (hereinafter referred to as Alpine rocks). The extraction and production of these axeheads, as seen later in the TRB, were highly elaborate. Furthermore, they were transported over long distances in exchange networks, modified regionally, and accumulated over an extended period. The presented Neolithic depositions can thus be interpreted as accumulations of invested time, considering both their manufacturing efforts and the biography of their objects.

Keywords Depositions, Neolithic Axeheads, Axehead Manufacture, Time Investment, Funnel Beaker Culture

Introduction – Place and Time of the Study

This paper explores the extent to which Neolithic depositions of heavy stone tools from Central and Northern Europe can be understood as representations of accumulated time or, more precisely, additional labour. The underlying idea is that the procurement of raw materials and the production of the deposited tools required time, diverting

resources from other tasks and thereby creating their value. Thus, in K. Marx's sense, values can be understood as crystallised labour (Marx 1867, 4; compare also Smith 2005, 31). Rather, as will be shown below, a significant portion of the deposited objects required the work of specialists, which Marx describes as complex labour and values higher than simple labour (Marx 1867, 4). The quantity of work itself is measured by its (necessary) duration (Marx 1867, 5). The longer the manufacturing time, the more value an object has (Smith 2005, 45; Ricardo 2001, 10–13). As these stone tools were deliberately deposited with no intention of retrieval, the accumulated time invested in their creation and, with this, their value was consequently sacrificed.

The study's starting point was the author's examination of depositions associated with the TRB (Müller 2024) and the inquiry into the origins of this phenomenon (Müller 2023). The TRB (4100–2800 BC, abbreviated as TRB) represents the first fully Neolithic culture in Northern Europe, characterised by monumental megalithic burial structures (Midgley 1992; Müller 2017), causewayed enclosures (Andersen 1997; Klassen 2014), and a complex deposition practice[1]. The term »culture« has been questioned as a summation of Funnel Beaker period societies (Furholt 2014), and some advocated for a thoughtful and ethnically detached approach to the concept of culture decades ago (Lüning 1972). In this article, the term Funnel Beaker period primarily refers to the aforementioned period in the present-day regions of the Northern Netherlands, Northern Germany, Poland, Denmark, Southern Sweden, and Southern Norway. During this epoch, various groups of people used primarily vessels with funnel-shaped rims and were the actors behind the phenomena mentioned above.

The origin of the TRB was long understood as an evolution from the Northern European Mesolithic Ertebølle Culture (Midgley 1992, 40–41; Koch 1998, 55), with parallels to Neolithic groups in Central Europe seen as cultural appropriation (Klassen 2004). The aDNA revolution deconstructed various theories (Koch 1998, 47–51) of Mesolithic societies transforming into Neolithic societies. It was people from Neolithic Central Europe who migrated into the area of the Ertebølle Culture[2] and established themselves after three centuries. The adaptation and development of technological complexes and traditions brought by Neolithic settlers to their new environment occurred, and clear references to their origins, such as the Michelsberg Culture or the Lengyel Culture, remain visible in ceramic vessel shapes and decorations, axeheads, enclosures, and deposition practices[3]. Over time, other Neolithic phenomena existing elsewhere in Europe were integrated, such as the megalithic burials (Müller 2011, 5–10). These developments, in addition to the arrival of stone and copper artefacts or their imitations in Northern Europe, reveal the existing pan-European networks at that time (Klassen 2000; Zápotocký 1992; Sørensen 2014).

Neolithic Depositions of Heavy Stone Tools in Northern and Central Europe

In this study, depositions are understood as ritual relinquishments of objects, deliberately laid down with no intention of retrieval (Seiwert 1998, 269). Other interpretative approaches have been excluded throughout the research, as they, at best, explained only parts of the overall phenomenon of the millennia-long practice of depositing objects (Müller 2024).

The »recipients« of these offerings remain unknown and are challenging to discern due to the limited available information. The identification of the ritual nature of depositions becomes possible when it can be demonstrated that they exhibit formalisation, structuring, and repetition (Tambiah 2008, 227–228). An examination of the categories of orchestration (composition), localisation (deposition location), and staging (deposition method), along with an assessment of the regularity of specific patterns, has proven insightful for this purpose (Müller 2024).

Neolithic deposition practices, especially during the Funnel Beaker period, are highly diverse, involving a wide range of objects made from materials such as stone, ceramics, amber, copper, and bone, deposited at various locations[4]. Deposition sites include different locations within settlements (wells, post pits, hearths, settlement pits), those in close proximity to graves[5], depositions in various areas of causewayed enclosures (Andersen 2000; Larsson 2012; Müller 2024), as well as depositions far from all these mentioned locations[6]. The last group, due to the deposition locations far from Funnel Beaker period structures, can be referred to as external depositions (Müller 2024). While they represent the majority of deposition sites, it should be noted that depositions from settlements, graves, and enclosures are relatively poorly researched and likely less frequently identified to date. Among the approximately 1200 external deposition sites of the TRB, those with stone tools dominate with around 1000 sites, three-quarters of which consist of single-type axehead hoards, and 13 % multi-type hoards containing at least one axehead (Fig. 1). Axeheads can thus be understood as a central theme in the Funnel Beaker period deposition practice, a notion reinforced by the widespread occurrence of this deposition form within the Funnel Beaker region[7]. The objects can be ready-to-use, used, and unused axeheads made of flint, their preforms, and raw materials, with only about 3 % of depositions containing axeheads made of igneous rock. Axeheads were, with few exceptions, deposited unhafted, indicating that at least the ones proven to be used (see below) must have been hafted before deposition. Hoards typically comprise two to three axeheads (Fig. 2), although larger ensembles or single-piece depositions have also been identified. At the beginning of the TRB axehead development (probably

1 Nielsen 1977; Rech 1979; Karsten 1994; Ebbesen 1995; Koch 1998; Wentink 2006; Kaflińska 2006; Müller/Hoffmann 2022; Müller 2024.
2 Skoglund et al. 2012; Malmström et al. 2015; Schulz 2015; Fraser et al. 2018.
3 Klassen 2004; Klassen 2014; Sørensen 2014; Müller 2023.
4 Nielsen 1977; Rech 1979; Bennike/Ebbesen 1986; Karsten 1994; Ebbesen 1995; Koch 1998; Klassen 2000; Müller 2024.
5 Ebbesen 1975, 159–162; Madsen 1979; Larsson 1992; Madsen 2019; Müller 2024.
6 Rech 1979; Karsten 1994; Ebbesen 1995; Müller 2024.
7 Nielsen 1977; Rech 1979; Karsten 1994; Wentink 2006; Kaflińska 2006; Müller 2024.

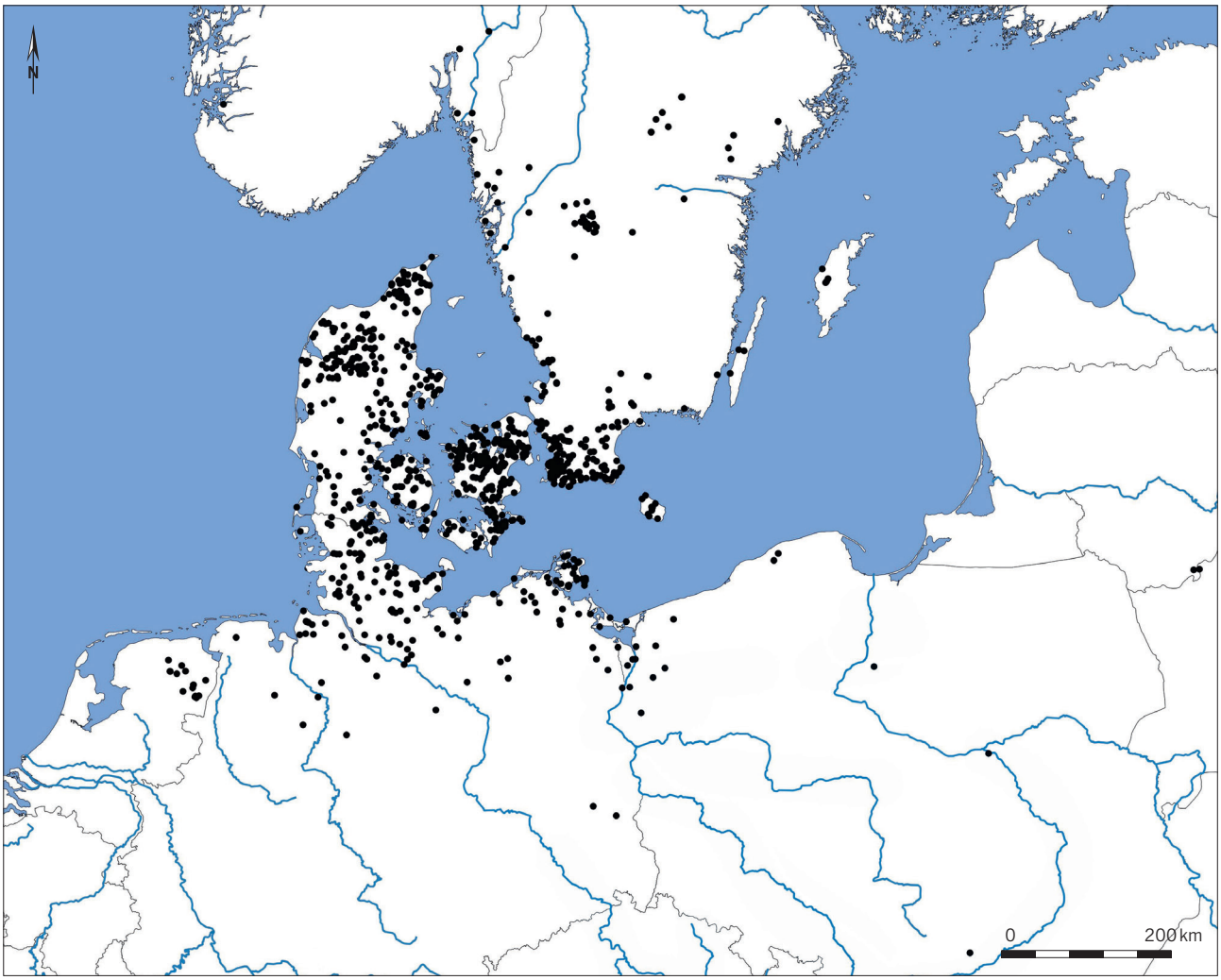

Fig. 1 The overall distribution of Funnel Beaker period hoards with axeheads.

Abb. 1 *Die Gesamtverbreitung trichterbecherzeitlicher Horte mit Beilklingen.*

from 4000 BC onwards; see Hirsch et al. 2008), there were two-sided pointed-putted forms, followed by four-sided pointed forms around 3800 BC (Hernek 1988; Nielsen 1977; Sørensen 2014, 67). These likely overlap temporally with the subsequent four-sided thin-butted forms (Klassen 2004, 210–211), which, in turn, have the longest duration within the TRB (3800–3000 BC). In the final phase of the Funnel Beaker period (3000–2800 BC), thick-butted axehead forms eventually replace the thin-butted ones (Davidsen 1978; Nielsen 1979; Strahl 1985). Alongside the thick-butted axeheads, a new form of double-sided pointed-butted axehead with a hollow edge – hence presumed to be hafted transversely – emerges (Nielsen 1979, 60). In addition to the edge form, these axeheads also differ in the extent of their surface grinding. Whereas early two-sided pointed-butted axeheads usually exhibit only partial grinding, focused on the cutting edge, finished four-sided pointed and thin-butted flint axeheads were completely ground on all four sides, from the cutting edge to the back, with only a few deeper-reaching flake negatives omitted (Fig. 2–3). Thick-butted axeheads in the Funnel Beaker period were typically only ground on the broad sides, with the narrow sides generally lacking overall grinding.

Within Funnel Beaker period depositions, between 30 and 70 % of axeheads, depending on the type, represent ready-to-grind preforms, meaning they were not functional axeheads (Müller 2024). This implies that their surfaces were worked by flint knappers to the point where only the grinding for their usability was missing (Fig. 4), a process that, however, never took place before the deposition of these axeheads. But when looking at the details, it is observed that, among the longest thin-butted axeheads, 80 % were deposited completely ground, while the shorter subtypes of thin-butted axeheads were deposited unground in up to 90 % of cases. In the Funnel Beaker period, particularly with thin-butted flint axeheads, mostly longer-than-average specimens were deposited, often exceeding a total length of 20 cm (see Fig. 11). The manufacture of these longer specimens required the expertise of specialists. The largest deposited axeheads known to date had lengths between 45 and 50 cm (Nielsen 1977, 127 No. 109; Sørensen et al. 2021, 8–10; Müller 2024). In contrast, axeheads known from settlements and graves are sometimes significantly less than 20 cm long (Ter Wal 1996; Lüth 2003). Often, rightly so, it is noted that the majority of deposited Funnel Beaker period axeheads, due to their extraordinary length and often accompanying slen-

Fig. 2 The Funnel Beaker hoard with three thin-butted flint axeheads from the Danish site Jegstrup, Central Denmark region, Inv. No. A 5691–5693.

Abb. 2 *Der trichterbecherzeitliche Hort mit drei dünnnackigen Flintbeilklingen vom dänischen Fundort Jegstrup, Region Midtjylland, Inv.-Nr. A 5691–5693.*

Fig. 3 The Funnel Beaker hoard with two four-sided pointed-butted flint axeheads from the Swedish site Falkenberg, Halland county, Inv. No. 45556–45557.

Abb. 3 *Der trichterbecherzeitliche Hort mit zwei vierseitigen spitznackigen Flintbeilklingen vom schwedischen Fundort Falkenberg, Hallands län, Inv.-Nr. 45556–45557.*

Fig. 4 The Funnel Beaker hoard with two unground thin-butted flint axeheads from the Swedish site Ystad, Skåne county, Inv. No. 14001.

Abb. 4 *Der trichterbecherzeitliche Hort mit zwei ungeschliffenen dünnnackigen Flintbeilklingen vom schwedischen Fundort Ystad, Skåne län, Inv.-Nr. 14001.*

der nature, were not suitable for woodcutting (Lüth 2003, 5–6; Wentink 2006, 53). Nevertheless, direct and indirect use-wear can be identified on the functional deposited tools from the Funnel Beaker period, which account for up to 80 % of the tools, depending on the type (Olausson 1983a, 28; Müller 2024). For thin-butted axeheads, these mainly involve smaller, rarely larger, damages to the cutting edge and re-sharpening processes. In contrast, however, only 25 % of the largest thin-butted flint axeheads show such traces.

The focus on heavy stone tools (adze heads, axeheads, shaft-hole axeheads and similar tools) in the deposition practice arose not only during the Funnel Beaker period, and it did not end with it. Already during the Central European Early and Middle Neolithic (5500–4400 BC), heavy stone tools were deposited. These include various forms of adze heads as well as axeheads and shaft-hole axeheads, which, as in the later Funnel Beaker period, were deposited unhafted[8]. For their production, mostly AHS and basalt were used

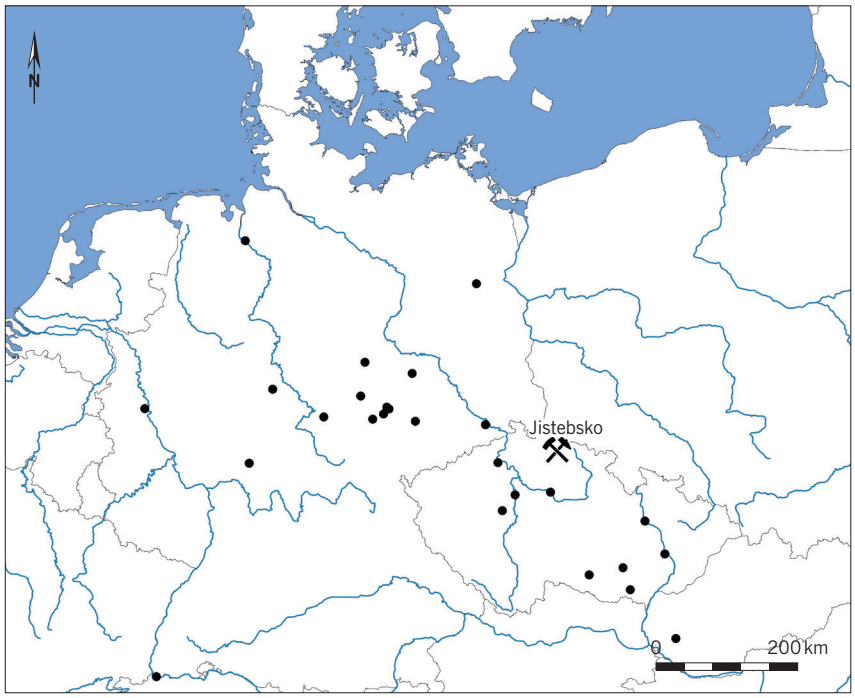

Fig. 5 The distribution of Early Neolithic hoards with heavy stone tools in Central Europe and the mining site of Jistebsko.

Abb. 5 *Die Verbreitung frühneolithischer Hortfunde mit schweren Steinwerkzeugen in Mitteleuropa und die Bergbauregion Jistebsko.*

(Ramminger 2007, 208–237; cf. Meinecke et al. in this volume). In a study area limited to the borders of present-day Denmark, Germany, Poland, the Czech Republic, and Slovakia, a total of 28 Early Neolithic or Linear Pottery Culture hoards (Fig. 5) and 82 Middle Neolithic (i.e., Stroke Ornamented Pottery Culture, Rössen Culture, and other) hoards with stone tools were identified, along with only three hoards exclusively containing small stone tools such as flint blades (Müller/Schirren 2022; Müller 2023).

In the heavy tools of the early Neolithic depositions (5500–4900 BC), so-called shoe-last adzes and flat hoes can be distinguished, which, according to B. Ramminger (2007), can be further subdivided using multivariate statistical methods. Early Neolithic hoards mostly contained three to four, but no more than nine, heavy stone tools or their preforms and raw materials (Fig. 6). In less than half of the depositions with preforms or raw materials, these were combined with ready-to-use tools. The latter have not been systematically examined for use-wear so far, but there are indications that such traces were present on the deposited tools (Quitta 1955, 45 No. 41). The length of ready-to-use adze heads from early Neolithic depositions ranges from 6 to 32 cm, with an average of 18.2 cm (Fig. 11), exceeding the average length of adze heads from contemporary graves (Ramminger 2007, 165 Fig. 151; Müller 2023, 267).

The tradition of depositing heavy stone tools apparently intensified during the Middle Neolithic (4900–4400 BC), resulting in a greater number of sites with a wider distribution (Fig. 7; Müller/Schirren 2022). While, especially at the beginning of this period, shoe-last adzes and flat hoes were still in use (Lönne 2003, 176) and deposited in hoards, it was subsequently the newly emerging shaft-hole axeheads, first in the form of perforated shoe-last adzes and later as so-called broad wedges (Schwabedissen 1967, 409) that dominated the deposition practice. Additionally, axeheads were deposited in these contexts. The stone tools of the Middle Neolithic groups in Central Europe (e.g., Rössen Culture, Stroke Ornamented Pottery Culture, Gatersleben group, or Jordanów Culture) are often challenging to differentiate without accompanying finds (Merkel 1999, 229–231; Kaufmann 2012, 390), making a specific allocation of depositions to one of these groups difficult, if not impossible. About half of the Middle Neolithic depositions contained two to three objects, but large hoards with up to nine tools, and exceptionally large hoards (Fig. 8) with over 50 tools, also exist (Vencl 1975, 13–18; Müller/Schirren 2002, 153 No. 109). The composition of the hoards shows various combinations of shaft-hole axeheads, shoe-last adze heads, flat adze heads, and preforms of these tools. In contrast to the Early Neolithic, preforms in the depositions are regularly associated with ready-to-use objects. An over-dimensioning can be observed, especially in the case of shaft-hole axeheads (cf. Fig. 11), which have an average length of 29 cm in hoards, while tools in settlements measure a maximum of 22 cm (Klassen 2004). Use-wear on Middle Neolithic tools from depositions has also not been systematically examined, but has been clearly documented in some cases (Müller/Schirren 2002, 146; Müller 2023, 268).

For the Central European Younger Neolithic (4400–3500 BC) in the distribution area of the Michelsberg Culture, away from settlements, graves, or circular enclosures, several (n = 22) hoards (Fig. 9) with two- and four-sided pointed-butted axeheads made of Alpine rocks (jadeite, omphacitite, or eclogite) can be identified (Pétrequin et al. 2012;

8 Quitta 1955; Vencl 1975; Salaš 1986; Müller/Schirren 2022; Müller 2023; Zamzow et al. 2024.

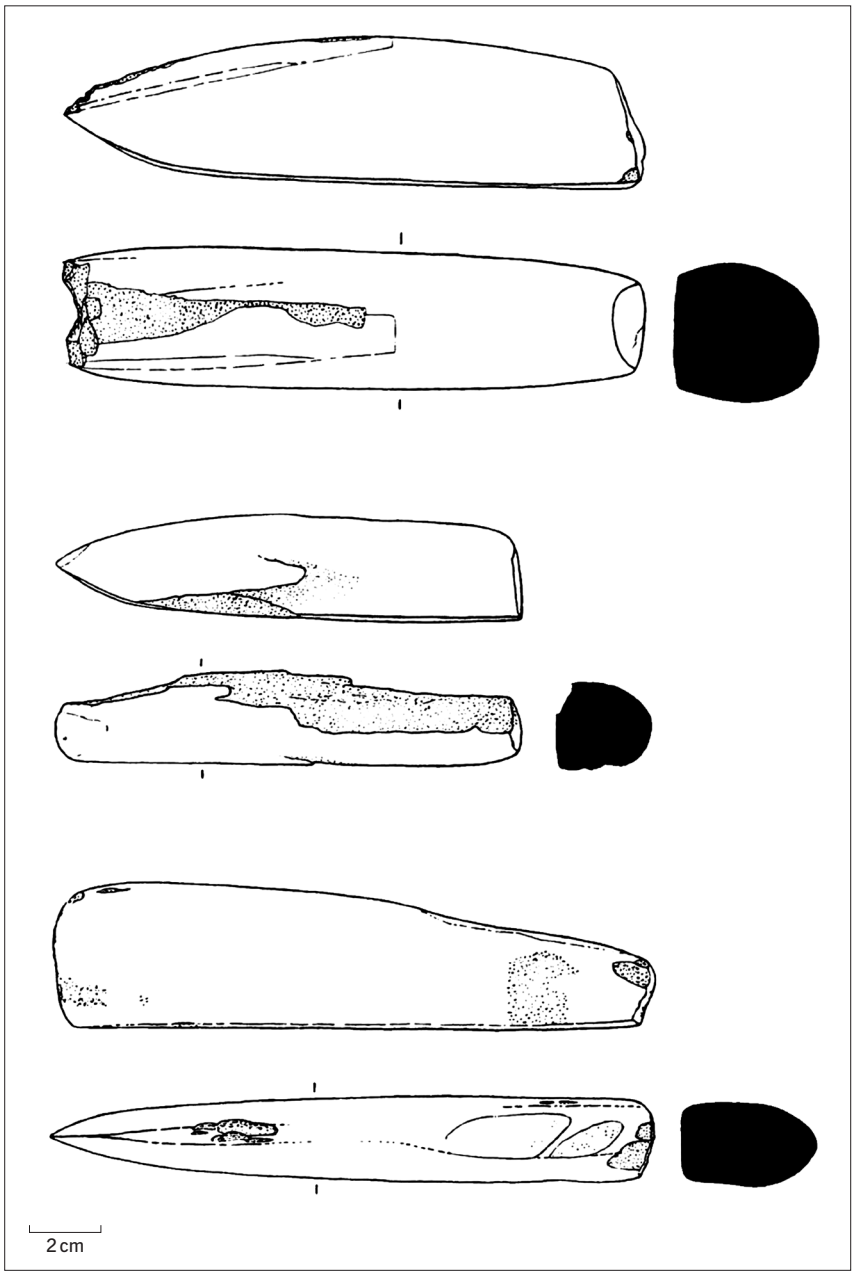

Fig. 6 The Linear Band pottery hoard from Liteň, Beroun district (Czech Republic), contained three shoe-last adzes.

Abb. 6 *Der linearbandkeramische Hort von Liteň, Okr. Beroun (Tschechische Republik), enthielt drei Schuhleistenkeile.*

Müller 2023, 269–271), usually summarised under the term Alpine jades (Pétrequin et al. 2008, 261) or Alpine rocks. In addition, axeheads made of flint (Pétrequin et al. 2012, 1438–1439) or copper (Pétrequin et al. 2012, 1438–1439; Matuschik 2012) occasionally occur in combination with axeheads made of Alpine rocks in these hoards. The axeheads made of Alpine rocks found in Michelsberg Culture depositions are most commonly attributed to the Puy and Altenstadt types, among others, including the Chenoise, Greenlaw, Chelles, or Durringten types (Pétrequin et al. 2012). Usually, two to three axeheads were deposited together, while larger hoards (Fig. 10) are very rare. Only one hoard contained preforms of axeheads that were deposited together with ready-to-use tools (Pétrequin et al. 2012, 1448–1451); otherwise, all known hoards consisted exclusively of ready-to-use axeheads. About 45 % of the axeheads made of Alpine rocks are longer than 20 cm (Fig. 11), contrasting with the maximum length of pieces described as working axeheads, which were more than 6 cm shorter (Jacobs/Löhr 2003, 155–157). The longest axehead from a hoard of the Michelsberg Culture measures 39 cm (Pétrequin et al. 2012, 1450–1451). The delicate shape of these large axeheads precludes their practical use. The repeatedly observed damages are therefore interpreted as intentionally caused (inter alia Klassen 2012, 1304; Knoche 2013, 299 footnote 4).

The origin of the raw materials for Neolithic stone tools

A significant and widely used raw material during the Central European Early and Middle Neolithic is actinolite-hornblende schist (AHS; Ramminger 2007, 208–237; Kegler-Graiewski 2007, 126; cf. Meinecke et al. in this volume). Since the discovery of the Neolithic quarry of this material in the Northern Bohemian part of the Jizera Mountains, especially at the Jistebsko site, Jablonec nad Nisou district (Fig. 5;

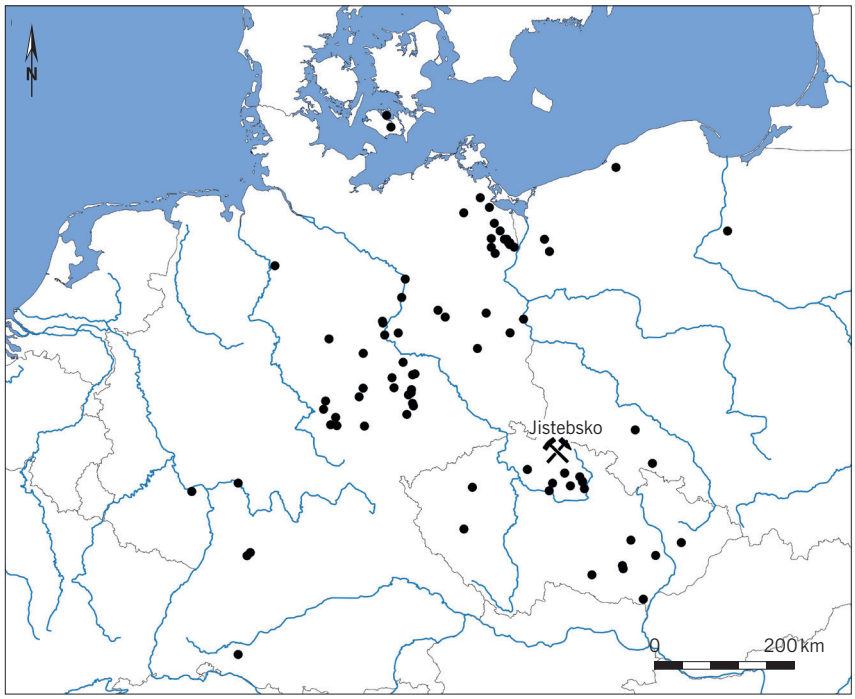

Fig. 7 The distribution of Middle Neolithic hoards with heavy stone tools in Central Europe and the mining site of Jistebsko.

Abb. 7 *Die Verbreitung mittelneolithischer Hortfunde mit schweren Steinwerkzeugen in Mitteleuropa und die Bergbauregion Jistebsko.*

Šída 2007), it has been widely assumed that the majority of the Early and Middle Neolithic demand for AHS was covered by this source (Kaufmann 2012, 391; Moník et al. 2021, 4). This not only implies transport routes of more than 600 km (Ramminger 2007, 239; Moník et al. 2021, 1) but also a well-functioning regional and intercultural (see below) network to sustain a continuous supply of raw materials for new tools. However, recent research (cf. Meinecke et al. in this volume) questions the X-ray fluorescence (XRF) method used previously for material analyses of AHS, focussing instead on certain minor elements not taken into account so far and employing Mineral Liberation Analysis for the first time. This approach reveals minimal differences in the material composition of widespread AHS resources, indicating that other, as yet unidentified, sources were used in the Neolithic for the heavy stone tools from Central Germany (see already Kegler-Graiewski 2007, 129). If this assumption proves correct, the proximity of certain regions to their respective raw material sources would be significantly reduced, improving their potential supply of AHS.

The supply of rocks summarised under the term Alpine rocks and the distribution of the axeheads made from them have been extensively studied (Pétrequin et al. 2012a; Pétrequin 2016). In the Neolithic, Alpine rocks were mined until around 3000 BC on the western side of the Alps at 1400–2400 m above sea level (Fig. 9, Monte Viso). The main extraction phase extended from 4700 to 3800 BC (Pétrequin in prep.). As early as the late sixth millennium BC, small axeheads and bracelets as well as larger axeheads were produced in present-day Italy (Pétrequin 2016, 418). As part of an exchange network extending up to 1700 km in the second half of the 5th millennium BC, some of the axeheads reached the distribution area of the Michelsberg Culture around 4300 BC[9], where the largest ones were deposited.

In contrast, for the axeheads made of flint during the Funnel Beaker period, primary and secondary flint resources were available in a wide part of the TRB distribution area (Fig. 12). These resources could produce both high-quality and lower-quality flint for tool production (Högberg/Olausson 2007, 23). Primary resources exploited during the Funnel Beaker period are located in Denmark, in Southern Sweden (Högberg/Olausson 2007, 18), on Rügen, and on Heligoland[10]. Secondary resources are found in moraine ridges or on beaches and mostly consist of a mixture of different types of flint, eroded by the ice ages from various primary resources (Högberg/Olausson 2007, 19). Glacially displaced flint occurs in different concentrations from the Netherlands through northern Germany to Pomerania. In the Funnel Beaker period, especially the east coast of present-day Schleswig-Holstein is significant for Northern Germany and the Netherlands since it is strongly influenced by the occurrence of secondarily displaced Southern Scandinavian flint, which also has large nodules of very good quality (Beuker 2010, 12). The extensive Funnel Beaker period sites in Poland (Balcer 1980) are not relevant in this context, as flint from there was not used to produce axeheads for depositions. Good flint was transported up to several hundred kilometres from the extraction site to supply areas without natural or with inferior flint resources (Olausson/Larsson 1982, 5). Neolithic flint mining in Sweden is documented in the region around Tullstorp, Södra Sallerup, and Kvarnby, Skåne län (Olausson et al. 1980; Högberg/Olausson 2007, 52). From the Danish peninsula of Jutland, a flint extraction site of the Funnel Beaker period is documented in the Hiller-

9 Jeunesse 2010, 50; Kreuz et al. 2014, 75; Bérenger 2015, 217; Baitinger 2017, 463.

10 Beuker 1988; Beuker 2005; Beuker 2011; Beuker et al. 2012

Fig. 8 The Middle Neolithic hoard with seven shaft-hole axeheads and two axeheads from the German site Friedefeld, Vorpommern-Greifswald district, Inv. No. ALM 2016/1385,1–1385,9.

Abb. 8 *Der mittelneolithische Hort mit sieben Axt- und zwei Beilklingen vom deutschen Fundort Friedefeld, Lkr. Vorpommern-Greifswald, Inv. Nr. ALM 2016/1385,1–1385,9.*

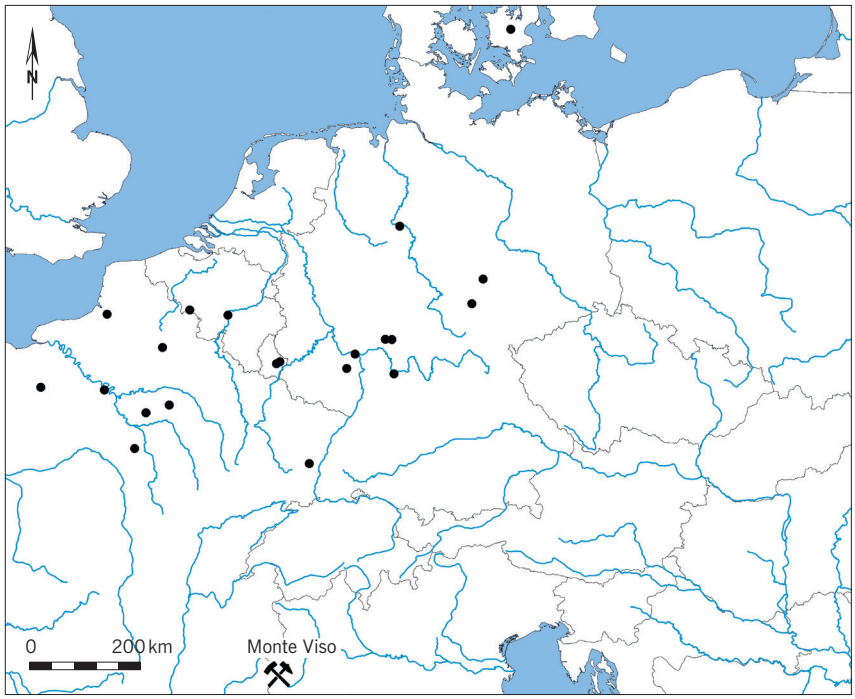

Fig. 9 The distribution of Michelsberg period hoards with axeheads of Alpine jade in Central Europe and the mining site of Monte Viso.

Abb. 9 *Die Verbreitung der michelsbergzeitlichen Horte mit Beilklingen aus alpiner Jade und die Bergbauregion Monte Viso.*

Fig. 10 The Michelsberg period hoard from Mainz-Gonsenheim contained five pointed-butted axeheads made of Alpine jade; no scale.

Abb. 10 *Der michelsbergzeitliche Hort von Mainz-Gonsenheim enthielt fünf spitznackige Beilklingen aus alpiner Jade; o. M.*

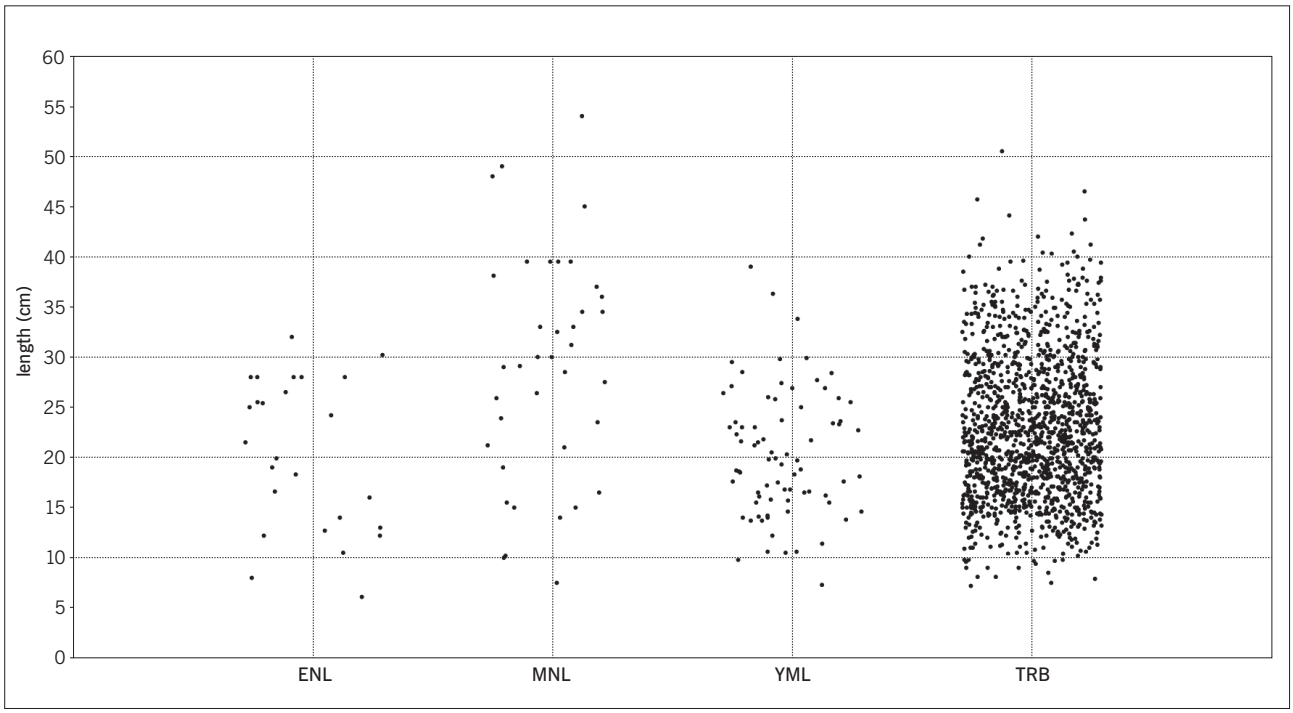

Fig. 11 On the jitter plot diagram, the lengths of heavy stone tools from hoards are plotted from the Linear Pottery Culture to the Funnel Beaker period.

Abb. 11 *Auf dem verwackelten Streudiagramm sind die Längen von schweren Steingeräten aus Horten von der Linienbandkeramik bis zur Trichterbecherzeit eingezeichnet.*

slev-Hov-Bjerre region (Midgley 1992, 233; Högberg/Olausson 2007, 51).

How were the heavy stone tools manufactured?

The manufacturing steps of axeheads made of AHS, Alpine rocks, or flint partly resemble each other, which is why they will be presented together below[11]. Of all three materials, flint, with a hardness of 7 on the Mohs scale, is the hardest. At the same time, due to its brittleness and lower elasticity compared to the other materials, it is very well suited for direct or indirect percussion (Weiner 1980, 216; Moník et al. 2021, 9). For the same reasons, flint is more likely to break (Moník et al. 2021, 10).

The first step in the production of heavy stone tools is the search for suitable raw material, which, especially in the case of large and extremely large objects from depositions, mostly comes from primary resources, although secondary resources cannot be categorically excluded[12].

For AHS, various processing forms have been proven to occur at the extraction site. The production of a significantly weight-reduced blank from the rock (Kaufmann 2012, 394) was carried out through direct hard percussion, sawing, splitting, or pecking (see below). The technique used depended on the size and shape of the raw piece. In general, sawing and splitting, significantly more laborious and time-consuming than the preparation by hard percussion, began only with the Stroke Ornamented Pottery Culture and the increased use of large river boulders (Ramminger 2007, 91; Šída 2007, 101–104; Moník et al. 2021, 4). However, these sawing marks have not been regularly identified in the territory of present-day Bohemia so far and might be a local regional phenomenon of Middle Neolithic groups connected to present-day Germany[13]. Sawing was then preferred as a method, especially for manufacturing very large artefacts (Šída 2007, 104). By selecting boulders from the river shores, the likelihood of fractures caused by disruptions in the rock, which had been eliminated by rolling in the water, also decreased (Šída 2007, 101; Kaufmann 2012, 394). In the sawing process, the material was not completely cut through; after creating a straight groove with a depth of 1–3 cm, it was disassembled by blows or the swelling of wooden wedges. A small stone slab could serve as a saw, which was either harder than the material to be sawn or contained harder particles (e.g., corundum). With the addition of water, a prepecked line served as a guide for this tool. The latter could also consist of bone, wood, or other materials if quartz sand was added as an abrasive. If possible, the natural stratification of the rock was followed[14].

11 For detailed information on flint, see Hansen/Madsen 1983, 45–47; Olausson et al. 1980, 195–199.

12 Olausson 1983a, 19–20; Šída 2007, 101; Pétrequin 2016, 418–420; Delgado-Raack et al. 2020, 774.

13 Pers. comm. R. Risch, Universitat Autònoma de Barcelona, and F. Trampota, Czech Academy of Sciences.

14 Ischer 1941; Quitta 1955, 24; Semenov 1964, 71; Hahn 1991, 228–229; Ramminger 2007, 93; Šída 2007, 102; 105; Kaufmann 2012, 394–395.

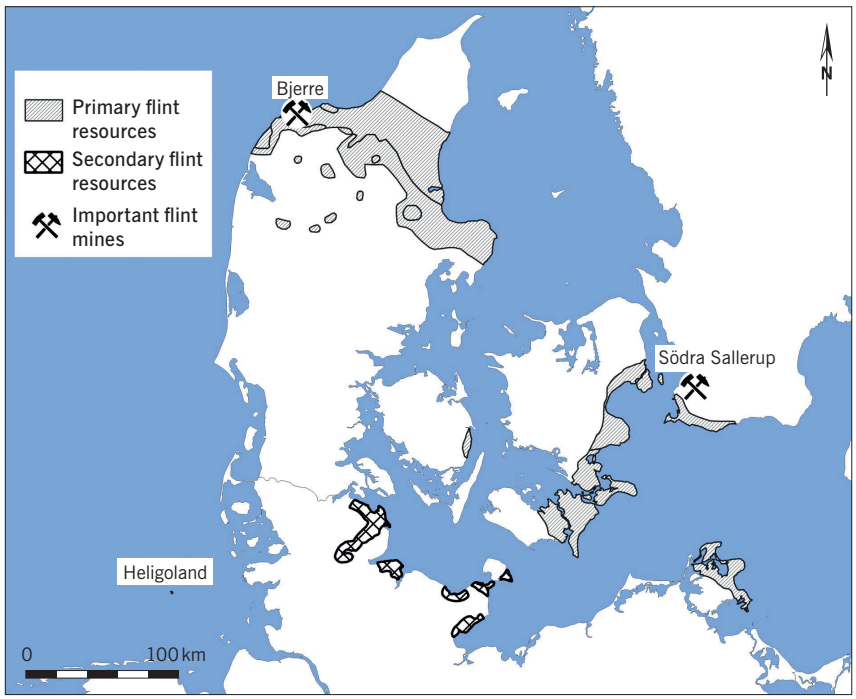

Fig. 12 The distribution of primary and secondary flint resources crucial for the production of Funnel Beaker period flint axe blades in Northern Europe.

Abb. 12 *Die Verbreitung der für die Herstellung der trichterbecherzeitlichen Flintbeilklingen wichtigen primären und sekundären Feuersteinressourcen in Nordeuropa.*

To reach the best sources of raw material for Alpine rocks, the bearers of the Square-Mouthed Pottery Culture (VBQ) had to go on a multi-day hike into the high mountains, where the material was not exposed to the pressure of glaciers. During the main extraction phase, Alpine rocks were detached using thermal shocks and then struck to the right size (Pétrequin 2016, 418–419). At the extraction sites, the hammer stones, axe blanks, and production waste also indicate a significant reduction in weight on-site; only the blanks were transported for further processing (Pétrequin et al. 2006, 12; Pétrequin et al. 2010, 193–194; Pétrequin 2016, 418). However, from the mid-5th millennium BC onwards, the sawing method using boards studded with granite chips was also employed for moraine jade (Pétrequin 2016, 420).

The quality of the raw flint material could be checked by first striking the flint nodules, allowing experienced flintknappers to identify surface-invisible cracks or larger fossil inclusions. Subsequently, in the hard percussion technique, protrusions and irregularities were first removed from the raw piece. The next step was the production of a blank, which is a roughly hewn, elongated, box-shaped work piece that has not yet reached the final shape of an axehead (Ebbesen 1980, 301; Hoika 1987, 44). In addition to hard direct percussion, the indirect percussion technique could also be used here (personal communication Harm Paulsen). A primary goal of this step, which still took place at the extraction site of the raw piece, was weight reduction to facilitate transportation for further processing (Fig. 13).

The next step in the production of heavy stone tools, which took place outside the extraction areas, was the further processing of the blank into a pre-shaped and ready-to-grind preliminary products by an experienced flintknapper. In addition to direct percussion, finer shaping possibilities for rocks such as AHS or Alpine rocks are provided by the so-called pecking technique (Šída 2007, 102–103; Pétrequin et al. 2017). This is a material-removing process in which a part of the surface of the workpiece is shattered or pulverised and detached by repeated blows (Semenov 1964, 66–68; Hahn 1991, 228; Goldhammer et al. 2012, 127). However, the physical properties of flint make it impossible to use this technique. Here, in the finer shaping process the indirect percussion technique was used, large, thin flakes were detached from the workpiece, and the final axehead shape was gradually worked out (Fig. 13). The final process before grinding involved straightening the side edges by alternating pressure retouching. In addition, the cutting edge was worked out by direct soft blows.

For Middle Neolithic axeheads made of AHS or other rocks, an additional step was required for the creation of a shaft hole. The designated area was prepared and roughened by pecking beforehand. For drilling, either a solid drill made of hardwood or a hollow drill made of a hollowed rod (e.g., elderberry) was used. In the latter case, the rock was only removed in a ring-shaped depression, creating a drill core as a by-product. The described drills were used with water and an abrasive (e.g., quartz sand) under fast rotation[15].

Grinding represents the last step in the production of the devices discussed here. The axeheads made of Alpine rocks were primarily ground by the inhabitants in the valley settlements of the Western Alps. However, from 4700 BC, many of the up to 46 cm long axeheads reached the 800 km distant Gulf of Morbihan in Brittany. On the way there, they were already made thinner and reshaped by further grinding in the Saône Valley, in eastern Burgundy, and in the Paris

15 Schuldt 1963; Hahn 1991; 229; Goldhammer et al. 2012, 127–128; Verhart 2012, 14.

Fig. 13 Examples of various production stages of thin-butted flint axeheads from Funnel Beaker period hoards. 1 Flint nodule with test strikes (Kindstrup, Denmark; Inv. No.A12537); 2 Core preparation (Asset, Denmark; Inv. No. A35129); 3 Flint blank (Kindstrup, Denmark; Inv. No. A12537); 4 Coarse preform (Skindbjerg Mose, Denmark; Inv. No. A39731); 5 Fine preform (Falster, Denmark; Inv. No. A8036); 6 Fully ground flint axehead (Snårestad, Sweden; Inv. No. 22624:1).

Abb. 13 *Beispiele für verschiedene Herstellungsphasen dünnnackiger Flintbeilklingen aus trichterbecherzeitlichen Horten; 1 Flintknolle mit Testschlägen (Kindstrup, Dänemark; Inv.-Nr. A12537); 2 Präparation des Kerns (Asset, Dänemark; Inv.-Nr. A35129); 3 Feuersteinrohling (Kindstrup, Dänemark; Inv.-Nr. A12537); 4 Fund mit grober Vorarbeit (Skindbjerg Mose, Dänemark; Inv.-Nr. A39731); 5 Fund mit feiner Vorarbeit (Falster, Dänemark; Inv.-Nr. A8036); 6 Fund mit vollständig geschliffene Flintbeilklinge (Schweden, Dänemark; Inv.-Nr. 22624:1).*

Basin (Bérenger 2015, 216). In Brittany, transformations also took place in the form of chamfers of the broad sides, neck perforations, or extravagant cutting-edge corners (Pétrequin et al. 2010, 193–194; Pétrequin et al. 2012a, 1015; Bérenger 2015, 216). All these modifications to axeheads made from Alpine rocks were possible without compromising their integrity due to their exceptional resistance to friction (Delgado-Raack et al. 2020, 791).

Of all the manufacturing steps, the grinding of flint axeheads is the most time-consuming process. In the endeavour to grind the entire surface, a very fine preliminary stage of manufacture was required for all types of rocks, preferably free of deeper negative bulbs. The progress of grinding is additionally dependent on the hardness and brittleness of the object to be ground, the applied contact pressure, and the grinding stone used. Grinding was carried out solely with the addition of water on grinding stones, which ideally were quartz-bound sandstones with a high abrasive effect due to quartz. Contrary to common belief (e.g., Thiele 1982), sand was not added as an additional abrasive, as it would only be crushed and prevent direct contact of the work piece with the grinding stone (Hein et al. 2024). A fine-grained grinding stone was used for the ultimate sharpening of the cutting-edge area (Olausson 1983a, 60).

In a final – but optional – stage, sand could be employed, especially for the axeheads made from Alpine rocks (pers. commun. W. Hein, Reichelsheim) in order to create an overall glossy surface polish. Alternatively, soft materials such as leaves or leather, or simply the same materials as the axeheads, could also be used (Delgado-Raack et al. 2020, 775).

How much time was spent on the production of the deposited stone tools?

It can be observed that the surfaces of the deposited axeheads, shaft-hole axeheads, and adze heads considered here were mostly fully ground to a ready-to-use state. In the case

of the TRB, this of course applies, as mentioned above, only to the thin-butted axeheads and some of the pointed-butted axehead types. However, the thin-butted axeheads constitute about three-quarters of all deposited flint axeheads from the Funnel Beaker period. Especially for flint axeheads, due to their high hardness (see above), a deep grinding, leaving virtually no negative flake bulb on the surface, is a very time-consuming task. Nevertheless, about 80 % of the longest thin-butted axeheads from Funnel Beaker period depositions exhibit such comprehensive surface treatment (Müller 2024). While the first cohesive grinding surfaces are formed after an hour of grinding, it takes much longer to enlarge these surfaces. The reason is that, for the first surfaces, only the most exposed parts of the axehead surface need to be ground, and the contact surface on the grinding stone is still relatively small. Gradually, however, the surface is ground down to the deeper areas. As a result, the contact surface to the grinding stone steadily increases, which in turn increases friction, so that the applied force must also be increased. When almost the entire surface of one side of an axehead has been ground, only a few deeper negative bulbs remain. However, to capture these, the entire axehead surface must be ground down (Olausson 1983a, 5). Therefore, for axeheads to be ground, it is generally important, as mentioned above, that the preparatory work is particularly fine and the surface is free of major indentations if the entire surface is to be covered by the grinding.

Although hardly any experimental data have been collected so far for the processing of heavy stone tools from ground stone, it can be generalised from the data that creating a grinding-ready preliminary product likely took longer than for equally long counterparts made of flint, as the knappability of rocks is worse than that of flint. In contrast, many types of ground stone can be ground up to three times faster due to their lower hardness compared to flint (see below; Olausson 1983, 28–33).

Especially for large tools made of AHS, whose Mohs hardness is between 5 and 6, two time-consuming steps must be added, namely, the sawing described above and, for the shaft-hole axeheads, the creation of the shaft hole by drilling. Modern experiments suggest that the hollow drilling method is less time- and labour-intensive compared to the solid drilling method (Goldhammer et al. 2012, 128). In general, drilling is labour-intensive: depths of between 0.40 and 0.75 mm per net hour are achievable, depending on the drilling technique and the material (Hahn 1991, 229). Furthermore, based on intensive comparative material studies, it was demonstrated that AHS is very difficult to grind, thus requiring considerable time and effort (Moník et al. 2021, 10), but it was nevertheless notably easier to shape than jadeitite (see below; Moník 2021, 12).

Alpine rocks, specifically jadeitite, approach the hardness of flint with a Mohs hardness of 6.5. According to reports, the weight removal during the grinding of axeheads of 2–3 g of material per hour (Pétrequin et al. 2017a, 363) is still significantly lower than that of flint (see below), probably due, among other factors, to the extreme density, fine-grained nature, and toughness of jadeite[16]. Accordingly, a grinding time of 100 net hours is indicated even for a jadeitite axehead of only about 20 cm in length (Pétrequin et al. 2013, 70).

For the time required to complete the deep grinding of flint axeheads with Neolithic techniques, some modern experiments can be cited[17]. Taking into account the of experimental flint knappers (thanks to, among others, W. Hein, K. Martens, H. Paulsen, and S. Stenak), a model overview of the net grinding times to be spent depending on the length and type of each flint axe head can be presented. It can be assumed that for a 20 cm long thin-butted flint axe head, a net grinding time of around 15 net hours (see below) was required for comprehensive deep grinding. For a 30 cm long axe head, it was already 30 net hours, for a 40 cm long axehead, 50, and for a 50 cm long axehead, up to 100 net hours (Müller 2024). The required net grinding time thus increases approximately exponentially with the length of the axehead. The exponential growth of net grinding time is explained not only by the larger surface area of particularly long axeheads but also by their more difficult handling on the grinding stone. It was predominantly important to avoid grinding beyond the edges of the grindstone or lifting the axe head partially out of the movement so that it falls back onto the grinding stone. Both would lead to damage or breakage of the long but delicate flint axeheads (Hein et al. 2024). The average weight removal of flint axeheads executed by manual grinding (without extra weight) is at least 6 g per hour (Hein et al. 2024), but can even reach between 7.5 and 12.0 g per hour (Pelegrin 2012, 99), which is significantly higher than that of jadeite. The net grinding time describes the active grinding time without breaks. However, since breaks are necessary solely due to physical exertion, a significantly longer gross grinding time must be expected, which, depending on the type and length of the axehead, could extend over several days, weeks, or even months if, as ethnological examples show, grinding was only sporadically continued (Burton 1984, 120). Grinding times contrast starkly with the time required to knap a ready-to-grind preparatory work for a flint axehead. For an axehead of 20 cm in length, only two net hours are estimated; for a specimen of 60 cm in length, only five net hours are assumed.

Discussion

The overview presented here illustrates that Neolithic depositions can be understood as representations of accumulated time in two ways: first, in the form of the time invested in individual objects, and, second, in the form of their circulation or period of use before being deposited, never to be taken up again. The illustrated manufacturing steps show that not only the pure processing time of a heavy stone tool must be taken into account but also the effort and duration of material procurement. However, significant uncertainties arise, particularly in the latter point, as the actually utilised

16 Pers. comm. W. Hein, Reichelsheim; Delgado-Raack et. al. 2020, 782–785.

17 Including Sehested 1884; Olausson 1983; Madsen 1984; Hahn 1991, 229; see also Hein et al. 2024 for a compilation and detailed discussion.

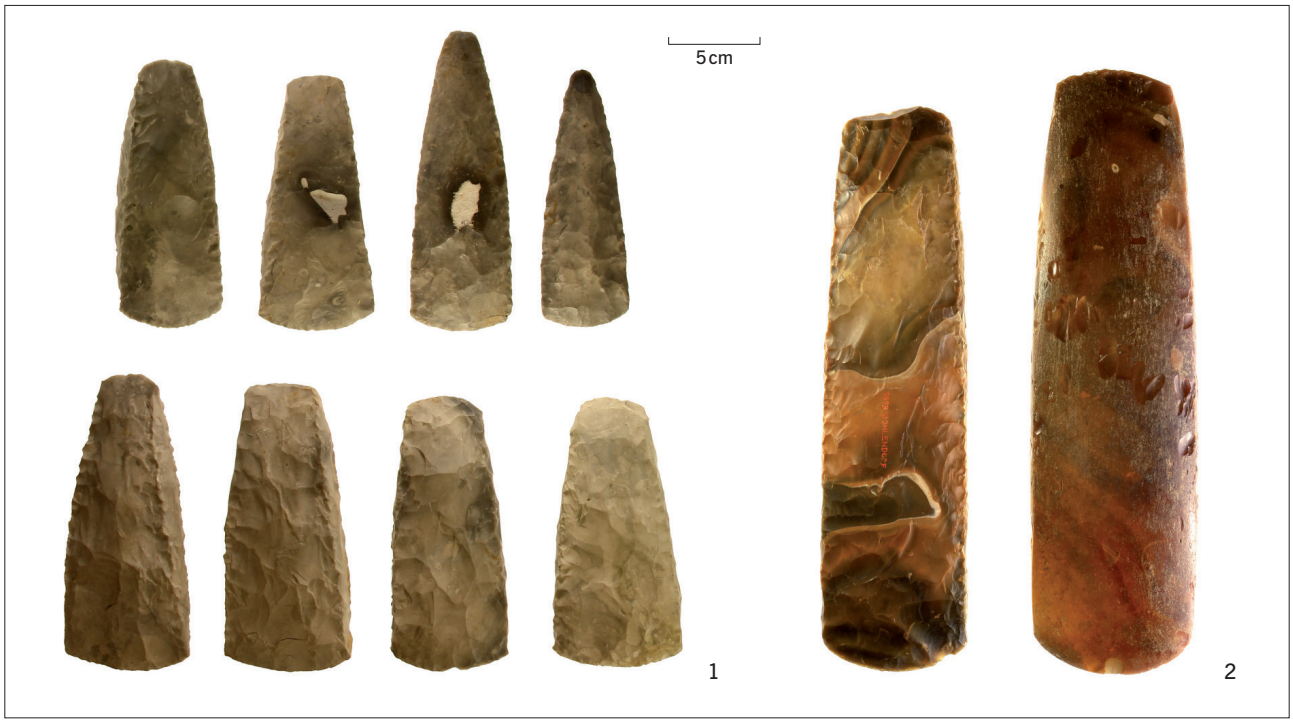

Fig. 14 The two Funnel Beaker period hoards with thin-butted flint axeheads from the Rügen sites Viervitz (1; Inv. No. SK7762a–h) and Bohlendorf (2; Inv. No. SK7579–7580) in comparison.

Abb. 14 *Die beiden trichterbecherzeitlichen Horte mit dünnnackigen Flintbeilklingen von den Fundorten Viervitz (1; Inv.-Nr. SK7762a–h) und Bohlendorf (2; Inv.-Nr. SK7579–7580) auf Rügen.*

resources and the logistical effort involved are often challenging to precisely determine. More reliable figures regarding the time investment were obtained through the experimental replication of stone tool production. But what is the benefit of this knowledge? The approximate assessment of the manufacturing times of heavy stone tools provides a different way to compare depositions than just the sheer number of objects. A hoard of eight unground flint axeheads of approximately 15 cm in length adds up to only about twelve net hours of manufacturing time, whereas a hoard with two thin-butted flint axeheads, each of about 30 cm in length, of which only one is ground, represents over 40 net hours of labour (Fig. 14). Even if the two axeheads in the latter hoard were only 15 cm long, the hoard with a total of 13 net hours of invested manufacturing time would surpass the hoard with the eight unground axeheads. Furthermore, entire regions can be investigated and compared based on the accumulated time of their depositions and additionally correlated to other phenomena, such as the effort required for megalithic graves (Wunderlich et al. 2024). Assuming that individuals in various Neolithic communities knew how long the procurement of raw materials, manufacturing, and especially the grinding of heavy stone tools took, and that the manufacturing became more complex and time-consuming as the tools grew larger, it can be presumed that this had an impact on the appreciation of stone tools. Among the flint axeheads in depositions of the Funnel Beaker period, as noted above, it was especially the longest ones that were disproportionately often deposited in a fully ground state (Fig. 15). Ethnological studies of societies in Papua New Guinea, which had a ritual focus on axeheads, also indicate a high appreciation for large axeheads produced with a large time investment[18]. Such sources provide important insights for interpreting analogous Neolithic phenomena.

Certainly, the concept of time in the Neolithic may have been quite different from today. However, the time invested in large stone tools is visible in them, petrified, and many within the same society would be aware of the time invested when viewing such a stone tool. Those spending time on the production of these prestigious stone tools would not be able to do anything else. However, in order to be able to spend time creating these kinds of items of value, a surplus of time, which at the same time means a surplus of food, must have been available (Bertemes 2018, 75; Gronenborn et al. 2018, 204–208). Therefore, the manufacturing of items of value is nothing less than the transformation of these surpluses (Bailey 1983, 181–183). But in order to sustain the value of such items, they have to remain rare, and for this reason, the irreversible deposition of these items is the logical step. So, in order not to be forced to destroy them, a taboo has to be created, in which these items transfer into a different state where they cannot be taken back.

In the context of the theme of time, other observations are noteworthy, which also become most evident in Funnel Beaker period hoards, namely, that a high proportion of unground axeheads, i.e., preliminary products, repeatedly

18 E.g., Malinowski 1934, 193–195; Højlund 1979, 39; Burton 1984, 90; Pétrequin 2007, 6.

Fig. 15 Two of the largest ever-discovered flint axeheads of the Funnel Beaker period, which were found in the hoards of Jegstrup, Central Denmark region (Denmark; 1; Inv. No. A5691), and Barnegården, Värmland county (Sweden; 2; Inv. No. 674:1).

Abb. 15 *Zwei der größten jemals entdeckten trichterbecherzeitlichen Flintbeilklingen aus den Horten von Jegstrup, Region Midtjylland (Dänemark; 1*; Inv.-Nr. A5691*), und Barnegården, Värmlands län (Schweden; 2*; Inv.-Nr. 674:1*).*

entered the hoards (Fig. 4 and 14). The time-consuming process of grinding was not completed here before deposition. preliminary products, as mentioned previously, also entered stone tool hoards in most other Neolithic epochs. The question arises here: Why was the time not taken to finish all tools before their deposition in order to represent a higher value of accumulated time and thus increase the value of the hoard? Was the timing of depositions perhaps not predictable over a long period but dictated by external circumstances, such as conflicts, disasters, discoveries, or other unforeseeable events? Or were the unfinished stone tools in the depositions deliberately representative of those into which additional hours, days, or weeks would have had to be invested? Perhaps it was even a conscious deception of the powers to whom they were sacrificed, comparable to the Greek myth of Prometheus' sacrificial fraud (Hesiod, Theogony, lines 530–550).

But why were many types of heavy tools fully ground at all? For their functionality, only the grinding of the cutting edge was crucial since only the cutting edge and only the outermost centimetres of it had direct contact with the wood to be struck. For axeheads made of ground-stone, the cutting edge was sharpened through grinding, ensuring stability for both flint and ground-stone axeheads (Olausson 1983a, 58). This means that an irregular cutting-edge surface leads to an undirected distribution of the forces encountered during wood striking, risking fractures (Olausson 1983a, 62). The fact that a minimal amount of grinding was entirely sufficient is demonstrated not least by the Funnel Beaker period flint axeheads, which often exhibit deep grinding only in the lower third of the tool (Strahl 1990, 231). Grinding the entire broad sides of axeheads also brings no advantages for their hafting since they only have contact with the handle on the narrow sides. For a shaft-hole axehead, this question does not even arise due to its different hafting method. Therefore, there are no convincing arguments for the complete surface grinding of heavy stone tools, and yet it was practiced by many cultures. Ultimately, the choice to extend surface grinding beyond the cutting edge largely depends on social or individual factors (Delgado-Raack et. al. 2020, 774). Moreover, this type of surface treatment also concerns those tools which, as mentioned above, due to their size, slender shape (axeheads of Alpine rocks and Funnel Beaker period flint axeheads), or heaviness (Middle Neolithic axeheads) were no longer practically usable. However, as demonstrated, even the largest specimens show use-wear, raising the question whether this might be an indication of their period of use before deposition and thus about accumulated time in a completely different sense. The damages to the cutting edge interpreted as use-wear could, for example, simply have happened through accidents or through the incorporation of the tools into performative ritualised acts or practical actions

away from wood striking. References to such use of oversized axeheads are reported from the Highlands of Guinea, where they were used, for example, to strike off finger joints as a sign of mourning (Højlund 1979, 42).

Evidently, the axe heads made of Alpine rocks remained in circulation for a long time and underwent many modifications during their journey through various European regions before they were deposited by the bearers of the Michelsberg Culture. The journey and long history of these axeheads may have been known and continuously shared by those who used or collected them[19]. At the very least, it must be assumed that their distant origin – from the perspective of some regions – and thus their »journey« were known. In Northeastern Germany, where the highest concentration of depositions is shown in the Middle Neolithic (Müller/Schirren 2022), the raw material sources were far away, whether they were in Northern Bohemia or Central Germany. Another aspect comes into play: If, despite all the objections mentioned above, heavy tools from Jistebsko reached the present-day regions of Germany, then the bearers of the Stroke Ornamented Pottery Culture from Jistebsko must have been responsible for the initial steps of the manufacturing process. However, the final steps were carried out again by bearers of other Middle Neolithic cultures in an early form of cross-cultural division of labour (Kaufmann 2012, 394). The same naturally applies to the axeheads made of Alpine rocks, which were initially processed by the bearers of the VBQ (Pétrequin et al. 2010, 193–194) before being further exchanged and modified.

Conclusion

The presented data and considerations lead to the conclusion that Neolithic depositions with heavy stone tools indeed represent an investment of additional time or labour. On the one hand, there is the time invested in manufacturing primarily extraordinary tools, which were also meant to be sacrificed, and, on the other hand, there is the period of circulation before these objects were deposited. The value of deposited shaft-hole axe and axeheads can be examined on various levels. The time encapsulated in stone endowed the deposited tools with a value, named *production value* (Delgado-Raack et al. 2020, 773), which bestowed significance upon them within social communities and could be understood by all their members. Therefore, it can be concluded that objects requiring greater labour had higher production values (Smith 2005; Ricardo 2001; Marx 1867), suggesting that many of the deposited Neolithic axeheads must have held the highest values within a society. However, since the exact use of the tools before deposition remains unclear, no reliable statement can be made about their *use value* (Delgado-Raack et al. 2020, 773). As the oversized deposited tools did not allow for conventional practical use in terms of tree felling, their use value in general cannot be compared to that of everyday tools. Instead, the *exchange value* (Delgado-Raack et al. 2020, 773) of the deposited axeheads likely played a role during the phase preceding their deposition. For exchange value, besides material criteria, aesthetic considerations are significant, which can be applied to many of the deposited objects even from a contemporary perspective. In conclusion, it can therefore be assumed that the social significance or value of axeheads was deposited with them.

However, the factor of additional time spent on extraordinary objects alone cannot have been decisive for the composition of hoards; otherwise, the presence of numerous unground stone tools or preliminary products in the depositions could not be explained. Clearly, other factors must have played a role in the composition of these depositions, which can only be speculated about.

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19 But for a contrasting view, see Delgado-Raack et al. 2020, 792.

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Warum und von wem wurden so viele Kriegsbeile begraben? Überlegungen zu Verbreitungsbild, Auffindungssituation und Auffindungszustand von Streitäxten der frühen Trichterbecherkultur

Jonas Beran

Summary

Who buried all those hatchets – and why? Reflections on the distribution pattern, location, and state of discovery of battle axes of the early Funnel Beaker Culture

One of the most common and impressive groups of Neolithic stone battle axes were initially named »polygonal battle axes« but are now mostly called flat hammer axes and knob-butted hammer axes. Around 155 specimens were known in Central Germany by 1991, and M. Zápotocký (1992) recorded a total of 1382 examples in his Central and Northern European working area. These axes have almost always been recovered as isolated finds; many of them come from water bodies and wetlands, and occasionally they have been recovered from earthworks, hilltop settlements, and other sites interpreted as settlements.

What is striking, and in need of explanation, however, is their complete absence in the Middle Elbe-Saale area, which is otherwise so rich in finds of stone axes. Two different explanations have been posited to solve this problem. According to J. Müller (2001), whereas the people of the Baalberge Culture, who inhabited the region at this time, also possessed these axes, they only ritually deposited them outside the settled areas. According to another view, the Baalberge people thought these axes signified the people of the Michelsberg Culture and Trichterbecher Culture (TBK), whom they considered foreign or even hostile. The characteristic concentration of axe findspots along the borders between cultural territories could thus also reflect territorial conflicts.

Be that as it may, the question arises: How can one imagine such ritual depositions? Perhaps they were ritual acts, such as the hatchet-burying ceremony of the Iroquois and other native North American peoples. This practice involves concealing, laying down, or burying the symbols of one's martial prowess in special places from which they could be brought out and presented at annual celebrations or whenever else they were required.

Sometime in the middle of the 4th millennium, however, the typological development of these axes broke off without continuation; the production, but probably also the significance and use, of the knob-butted hammer axes came to an end. Thereafter, the completely new development of »double-edged axes« begins, starting with the round-butted axes of the south-central European tradition and ending centuries later with the crest-butted axes of the Globular Amphora Period. Chronologically, the change between these fundamentally different TBK axe shapes coincides with the boundary

Zusammenfassung

Eine der häufigsten und eindrucksvollsten jungneolithischen Typengruppen steinerner Streitäxte wurde ursprünglich als »vielkantige Streitäxte« bezeichnet, jetzt jedoch meist als flache Hammeräxte und Knaufhammeräxte. Um 1991 waren im mitteldeutschen Raum 155 Exemplare bekannt und M. Zápotocký (1992) verzeichnete für sein gesamtes mittel- und nordeuropäisches Arbeitsgebiet insgesamt 1382 Stücke. Es handelt sich fast immer um Einzelfunde, oft aus Gewässern und Niederungen, gelegentlich aus Erdwerken, Höhensiedlungen und anderen als Siedlungen interpretierten Fundplätzen.

Auffallend und erklärungsbedürftig ist nun allerdings das komplette Nichtvorhandensein im sonst so fund- und steinaxtreichen Mittelelbe-Saale-Gebiet. Dazu stehen zwei verschiedene Interpretationsvorschläge im Raum. Nach J. Müller (2001) besaßen die Menschen der hier in dieser Zeit existierenden Baalberger Kultur zwar auch diese Äxte, sie wurden von ihnen aber grundsätzlich nur außerhalb der Siedlungsgebiete rituell deponiert. Nach anderer Auffassung galten diese Äxte den Baalbergern als Kennzeichen der als fremd oder gar feindlich wahrgenommenen Träger der Michelsberger und der Trichterbecherkultur. Die besondere Konzentration der Axtfundplätze entlang der Kulturgebietsgrenzen könnte damit auch Territorialkonflikte widerspiegeln.

In jedem Fall stellt sich die Frage: Wie kann man sich solche rituellen Deponierungen vorstellen? Möglicherweise als Zeremonien wie das Begraben des Kriegsbeils bei den Irokesen und anderen nordamerikanischen Völkern. Dabei werden die Symbole der eigenen Kriegstüchtigkeit an besonderen Orten verborgen, niedergelegt oder begraben und jeweils im Bedarfsfall oder bei jährlichen Feiern hervorgeholt und präsentiert.

Irgendwann in der Mitte des 4. Jts. bricht die typologische Entwicklung fortsetzungslos ab, enden Herstellung und wohl auch Bedeutung und Nutzung der Knaufhammeräxte. Ausgehend von rundnackigen Äxten südmitteleuropäischer Tradition beginnt die ganz neue Entwicklungsreihe der »doppelschneidigen Äxte«, die erst Jahrhunderte später mit den Nackenkammäxten der Kugelamphorenzeit endet. Zeitlich fällt der Wechsel zwischen den grundverschiedenen Axtformen der Trichterbecherkultur zusammen mit der Grenze zwischen nordischem Früh- und Mittelneolithikum, mitteleuropäischem Jung- und Spätneolithikum, mit dem Aufkommen der reich verzierten Tiefstichkeramik und der megalithischen Ganggräber, mit verstärktem Ausgleich und zunehmenden Einflüssen zwischen Nordwesten und Südosten. So ist dann wohl in einer gesellschaftlichen Umbruchzeit der ganze

between the Nordic Early and Middle Neolithic as well as the Central European Young and Late Neolithic. It also marks the emergence of the richly decorated, deeply incised pottery as well as the megalithic passage graves and the increased convergence and exchange between the north-west and the south-east. Thus, during a time of social upheaval, an entire range of cult accessories and signifiers was disposed of, and something completely new was initiated.

Keywords: Funnel Beaker Culture, flat hammer axes, knob-butted hammer axes, ritual deposition, distribution pattern

Bestand an Kultrequisiten und Feldzeichen geschlossen entsorgt und etwas ganz Neues angefangen worden.

Schlagwörter: Trichterbecherkultur, flache Hammeräxte, Knaufhammeräxte, rituelle Deponierung, Verbreitungsmuster

Allgemeines zu Flachen Hammeräxten und Knaufhammeräxten

Traditionell als Streitäxte benannte durchbohrte Felsgesteingeräte sind seit jeher ein besonders engagiert bearbeitetes Forschungsthema. Neben Gefäßkeramik und Grabformen bilden sie für den Zeitraum des 4. und 3. Jts. v. Chr. in Mitteleuropa und Südskandinavien wohl noch immer die meist beachtete Quellengruppe. Das Tagungsthema »Der soziale Wert prähistorischer Äxte« gab daher Anlass, ihnen, basierend auf früheren Publikationen (Beran 1991; Beran 1995; Beran 2014a), zwei Poster zu widmen, deren eines Grundlage der folgenden Ausführungen ist.

In erster Linie geht es bei der Interpretation der Streitäxte um ihren Wert als Waffen in mehr oder weniger ritualisierten Kämpfen (Meller u. a. 2015) und damit verbunden als statusanzeigende Grabbeigaben. An dieser Stelle soll aber eine frühe Typengruppe noch einmal unter etwas anderem Blickwinkel besprochen werden, nämlich hinsichtlich der möglichen Motive und Verfahrensweisen bei ihrer Deponierung außerhalb von Grabzusammenhängen.

Eine der häufigsten und eindrucksvollsten Typengruppen steinerner Streitäxte sind die ursprünglich so benannten »vielkantigen Streitäxte« (Åberg 1918, 48–52; Berlekamp 1963), später als X-Äxte (Jażdżewski 1936, 278 f.; 370 f.) und Knaufhammeräxte (Jażdżewski 1936, 273–278; 366–370), jetzt meistens als Flache Hammeräxte und Knaufhammeräxte bezeichnet (Brandt 1971; Grisse 2006, 82; 121; Ramminger 2010, 199 f.), bei M. Zápotocký (1992) entsprechend F-Äxte und K-Äxte. Um 1992 waren im mitteldeutschen und brandenburgischen Raum 188 Exemplare bekannt (Herfert 1962, 1113–1115; 1138; Beran 1993, 73–78; 80–82; 133 f.; 137; Beran 1995). M. Zápotocký (1992) verzeichnete für sein gesamtes mittel- und nordeuropäisches Arbeitsgebiet insgesamt 1382 Stücke.

Die Gesamtzahl der ehemals hergestellten Stücke könnte mindestens das Zehnfache betragen. Von den unterhalb der rezenten Pflugsohle in Erdwerksgräben oder Gewässern deponierten Äxten dürfte die Mehrzahl noch nicht gefunden worden sein. Zum Beispiel kennen wir aus dem Stadtgebiet von Magdeburg zwei Flache Hammeräxte aus Kieswerken in der Elbaue: Magdeburg-Salbke im Süden, Magdeburg-Neustadt im Norden (Herfert 1962, 1114 Nr. 99; Taf. XVI,3; Beran 1995, 34 Nr. 44, Abb. 1,2). Wenn wir versuchsweise annehmen, dass bisher etwa 10 % der holozänen Flusskiese ausgebaggert worden sind und vielleicht die Hälfte der dabei zutage geförderten Äxte bemerkt und geborgen worden ist, kämen wir für dieses Beispiel einer Stichprobe auf möglicherweise 38 weitere, in diesem Gebiet noch nicht entdeckte Stücke.

Im Unterschied zu den wohl Tausenden Grabfunden mit Äxten der endneolithischen Streitaxtkulturen des 3. Jts. v. Chr. gibt es mit ganz vereinzelten Ausnahmen keine Fla-

Abb. 1 Zeestow, Lkr. Havelland. Knaufhammeraxt mit erhaltenem Rest des Holzschaftes auf dem Grund eines ehemaligen Sees. Grabung S. Schwarzländer 2006.

Fig. 1 *Zeestow, Havelland district. Knob-butted hammer-axe with the preserved residue of a wooden shaft found at the bottom of a former lake. Excavation by S. Schwarzländer, 2006.*

Abb. 2 Potsdam, Schiffbauergasse, 2003. Auffindung einer flachen Hammeraxt »brandenburgischen Typs mit Mittelrippe« nach P. Herfert (1962) (vgl. Taf. 1,3) in einem Erdwerk der frühen Trichterbecherkultur. Arbeitssituation an der Fundstelle und das in diesem Erscheinungsbild selten dokumentierte erste ›Aufleuchten‹ des besonderen Stückes noch im groben Schaufelplanum.

Fig. 2 *Potsdam, Schiffbauergasse, 2003. Discovery of a flat hammer-axe of the ›Brandenburg type with a central rib‹ according to P. Herfert (1962) (see Pl. 1,3) in an earthwork of the early Funnel Beaker Culture. Working situation at the site and the first glimpse of the special piece (rarely documented in this appearance) still in the roughly shoveled planum.*

chen Hammeräxte und Knaufhammeräxte aus Grabfunden (Zápotocký 1992, 40 f.; 164–167). Sie sind fast immer Einzelfunde, oft auch aus Gewässern und Niederungen (Abb. 1)[1], gelegentlich in Erdwerken (Abb. 2; Grisse 2006, 92–94), auf Höhensiedlungen und anderen als Siedlungen interpretierten Fundplätzen.

Im Süden überwiegen Fragmente, im Norden ganze Stücke. Im Laufe der typochronologischen Entwicklung nimmt der Anteil unfertiger (unvollständig durchbohrter) Stücke zu, bei den Knaufhammeräxten sind sie bereits in der Mehrzahl.

Chronologisch-kulturell gehören die Flachen Hammeräxte in den jeweils so definierten Verbreitungsgebieten zu einer mittleren Phase (MK III) der Michelsberger Kultur[2] und zum frühneolithischen Abschnitt der nordischen Trichterbecherkultur (im Folgenden TBK; Brandt 1971; Madsen 1994, 330).

Auffallend und erklärungsbedürftig ist nun allerdings das komplette Nichtvorhandensein sowohl der Flachen Hammeräxte als auch der Knaufhammeräxte als deren typochronologischen Nachfolgern in zentralen Bereichen des sonst ja so fund- und steinaxtreichen Mittelelbe-Saale-Gebietes (Abb. 3–4).

Weiterhin fällt auf, dass die Knaufhammeräxte (Abb. 4) in einigen Regionen zu fehlen scheinen, wo eigentlich eine Besiedlung zur Zeit der jünger-frühneolithischen Trichterbecherkultur anzunehmen ist. Es deutet sich inzwischen an, dass die Äxte hier regional und funktional durch die sogenannten Dicken Flintspitzen (Lübke 1998) vertreten sein könnten. Diese sind im Fundbestand im Vergleich zu den Felsgesteinäxten sicher stark unterrepräsentiert, da sie als Flint-Großgeräte sekundär nachgenutzt und verarbeitet werden können und überdies als Fragmente schwer von spitznackigen Beilen oder von Dolchen zu unterscheiden sind[3].

Bemerkenswerterweise ist dieses eigenartige Verbreitungsbild der frühen TBK-Äxte in Mitteldeutschland bereits im späten 5. Jt. vorgezeichnet (Abb. 5): Deponierungen wertvoller und symbolträchtiger Großgeräte[4] scheinen die von Bauernbevölkerungen bandkeramischer Tradition eingenommenen Altsiedelgebiete (auf Abb. 5 etwa markiert durch die kartierten keramischen Leitformen) auszusparen. Als Deponierer der Äxte und Beile kämen somit wiederum entweder diese oder aber beweglichere, archäologisch schwerer nachweisbare Viehzüchtergruppen westeuropäischer Herkunft oder neben der donauländischen Bauernbevölkerung in den Hügelländern und anderen, weniger fruchtbaren Randlandschaften jahrhundertelang weiterlebende ›Restmesolithiker‹ in Frage.

Hinsichtlich der Flachen Hammeräxte (s. Abb. 3) stehen dazu zwei verschiedene Interpretationsvorschläge im Raum. Nach J. Müller (2001, 402 f.; 417 f.) besaßen die Träger der hier in dieser Zeit existierenden Baalberger Kultur zwar auch die Äxte dieses Typs. Sie wurden von ihnen aber grundsätzlich nur außerhalb der Siedlungsgebiete rituell deponiert.

Nach anderer Auffassung (Beran 1991; vgl. auch Geschwinde/Raetzel-Fabian 2009, 198; 204 Abb. 153) galten diese Äxte den Baalbergern als Kennzeichen der als fremd oder gar feindlich wahrgenommenen Träger der Michelsberger und der Trichterbecherkultur[5].

Nur von den beiden letzteren wurden demnach die Flachen Hammeräxte hergestellt, benutzt und aufbewahrt, dem entsprechend markieren ihre Fundpunkte das von ihnen eingenommene, genutzte und beanspruchte Gebiet.

1 Keiling 1989; Kirsch 1994, 59; Schwarzländer 2009, 48; Grisse 2006, 115; 161.

2 Willms 1982; Geschwinde/Raetzel-Fabian 2009, 198; Schwarz 2021, 49 Abb. 1; Schwarz 2021a, 233 Abb. 6; 234.

3 Auch dieser Frage soll im Zusammenhang mit einer in Arbeit befindlichen Neuerfassung der endneolithisch-frühbronzezeitlichen Feuersteindolche im nördlichen Sachsen-Anhalt (J. Beran und B. Fritsch) nachgegangen werden.

4 Im Zusammenhang mit dem Phänomen der Jadeitbeile schildert R. Schwarz Beispiele des möglichen Umgangs mit und der Aufbewahrung von wertvollen und symbolträchtigen Steinbeilen aus Neuguinea (Schwarz 2021a, 230), die auch hinsichtlich der hier angesprochenen Fragen zu den durchlochten Streitäxten interessant erscheinen.

5 Mit den »kurzen, gedrungenen, rundnackigen Äxten« (Herfert 1962, 1098 Taf. I–II; Preuß 1966, 29) verfügt die Baalberger Kultur über einen eigenen, von den Hammeräxten sehr verschiedenen Typ durchlochter steinerner Streitäxte, der wahrscheinlich in südmitteleuropäischer Tradition steht (vgl. Zápotocký 1986, 352 f. Abb. 3).

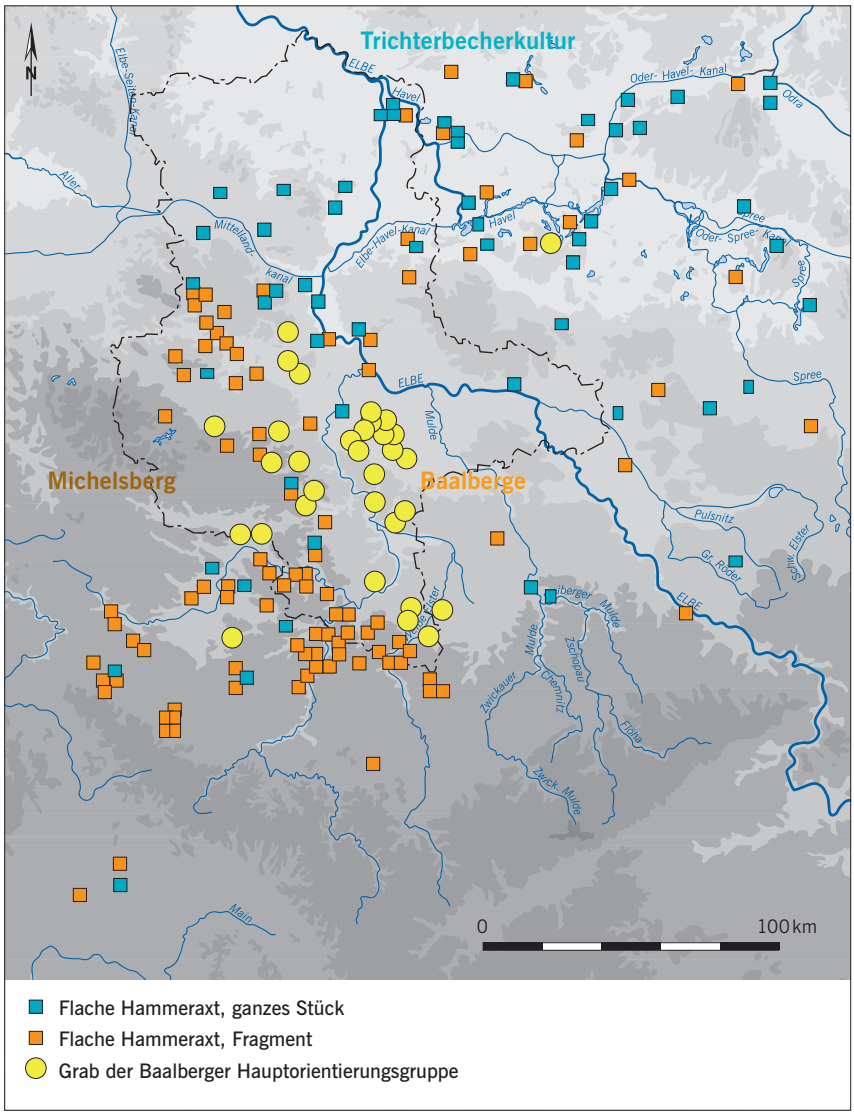


Abb. 3 Jungneolithische Kulturen und Verbreitung der Flachen Hammeräxte. Erfassungsstand um 1992; Niedersachsen und Böhmen nicht kartiert.

Fig. 3 *Late Neolithic cultures and distribution of flat hammer-axes. Recorded around 1992; Lower Saxony and Bohemia not mapped.*

Die besondere Konzentration der Axtfundplätze entlang der Kulturgebietsgrenzen könnte damit auch eine Widerspiegelung von Territorialkonflikten sein[6].

Dieses noch immer ungelöste Forschungsproblem war hier einleitend zu umreißen. Neue Erkenntnisse und Lösungsansätze gibt es dazu m. W. nicht. Im Folgenden sollen daher lediglich vor dem Hintergrund jahrzehntelanger Beschäftigung mit dem Thema und auch eigener Grabungsergebnisse einige Gedanken zum Phänomen der Streitaxtdeponierungen formuliert und zur Diskussion gestellt werden.

Überlegungen zu möglichen Deponierungsmotiven und -praktiken

Wie also könnte man sich solche rituellen Deponierungen vorstellen? Vielleicht waren es Zeremonien, wie sie vor allem als das »Begraben bzw. Ausgraben des Kriegsbeils« bei den Irokesen und anderen nordamerikanischen Indianervölkern selbst bei uns schon lange auch redensartlich populär sind (Stephenson 2013, 112; 115; Stammel 1992, 283–285; Lafitau 1987, 357 f.; 363; 368). Schilderungen finden sich im englischen Wikipedia-Artikel »Burying the hatchet«[7]: »A translation of Thwaites' monumental work Jesuit Relations, 1644, suggests the practice: ›Proclaim that they wish to unite all the nations of the earth and to hurl the hatchet so far into the depths of the earth that it shall never again be seen in the future.‹ [...] Samuel Sewall wrote in 1680 ›of the Mischief the Mohawks did; which occasioned Major Pynchon's going to Albany, where meeting with the Sachem they came to an agreement and buried two Axes in the Ground; one for English another for themselves; which ceremony to them is more significant & binding than all Articles of Peace the hatchet being a principal weapon with them.‹«

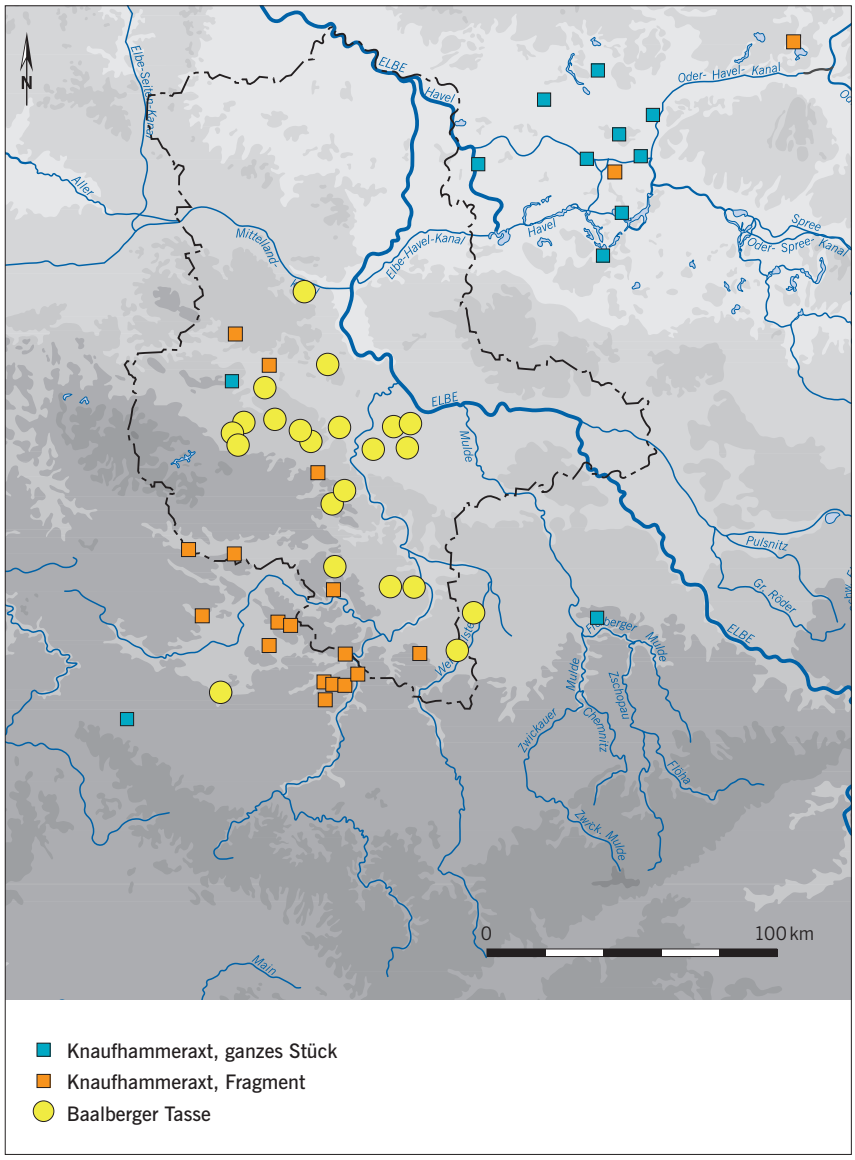
Die materiellen Symbole der eigenen Kriegstüchtigkeit wurden an besonderen Orten aufbewahrt, niedergelegt,

6 M. Müller und M. Schirren (2022, 135) interpretieren Deponierungen durchlochter und undurchlochter mittelneolithischer Felsgesteingeräte des 5. Jts. »als Raummarkierungen neolithischer Gruppen«, »die dazu dienten, neue Gebiete für sich in Anspruch zu nehmen oder bestehende Siedlungsareale abzugrenzen.«

7 <https://en.wikipedia.org/wiki/Burying_the_hatchet> (26.06.24).

Abb. 4 Verbreitung der Knaufhammeräxte im Verhältnis zu einer keramischen Leitform der Baalberger Kultur.

Fig. 4 *Distribution of knob-butted hammer-axes in relation to a ceramic type form of the Baalberge Culture.*



begraben, wie im Mittelalter die heilige Lanze oder der Säbel Sultan Osmans, und jeweils im Bedarfsfall oder bei jährlichen Feiern hervorgeholt und präsentiert. Die Aufbewahrungsorte der Äxte und möglicherweise auch anderer Dinge wären dann sozusagen funktionale Vorläufer etwa der Fahnenheiligtümer der römischen Truppen oder der Sakristeien der christlichen Kirchen.

Hier handelt es sich sozusagen um die Praxis der temporären oder saisonalen Deponierung von Kultrequisiten und Reliquien, mit aus heutiger Sicht fast musealem Charakter. Vor allem Fundpunkte auf Anhöhen legen derartige Szenarien nahe, wie z. B. die Lanzettaxt vom Kultplatz der Walternienburger Kultur auf dem Mühlenberg bei Buchow-Karpzow, Lkr. Havelland, Brandenburg (Kirsch/Plate 1984, Abb. 14,7; 21,1).

Für eine dem gegenüber sozusagen finale Deponierung sind wiederum auch viele verschiedene Gründe und Anlässe vorstellbar. In diesem Sinne sind wohl vor allem die zahlreichen Gewässerfunde zu interpretieren. Ihnen zugrunde liegen könnte einerseits eine Art beiläufiger Entsorgung nach Bedeutungsverlust oder aber auch ein dramaturgisch als Opferung zelebrierter feierlicher Akt. Seit jeher wirkt es besonders eindrucksvoll, wenn wertvolle und symbolgeladene Gegenstände von hohen Repräsentanten ins tiefe Wasser geworfen werden. Man denke an die vom Dogen von Venedig jährlich mit Versenkung eines goldenen Ringes zelebrierte Hochzeit mit dem Meer oder an Friedrich Schillers Balladen vom Taucher oder vom Ring des Polykrates.

Auch an eine im Rahmen sozialen Wettstreits zur Schau gestellte Reichtumsvernichtung in der Art der berühmten Potlatch-Feste der nordamerikanischen Nordwestküstenkultur könnte gedacht werden, speziell an die dabei verwendeten Ritualkeulen (La Farge 1975, 168 Abb.). An damit verbundene oder in anderem Zusammenhang vorgenommene Straf- und Disziplinierungsaktionen lassen die vielen halbierten Äxte denken, analog etwa zum öffentlichen Zerbrechen des Degens eines degradierten Offiziers im 19. Jh.

Das Zerteilen der Äxte und das unterschiedliche Behandeln und Aufbewahren der Hälften kann auch symbolischen und magischen Zwecken dienen (vgl. Lafiteau 1987, 364). Für endneolithische Äxte gibt es dazu bereits Befund-

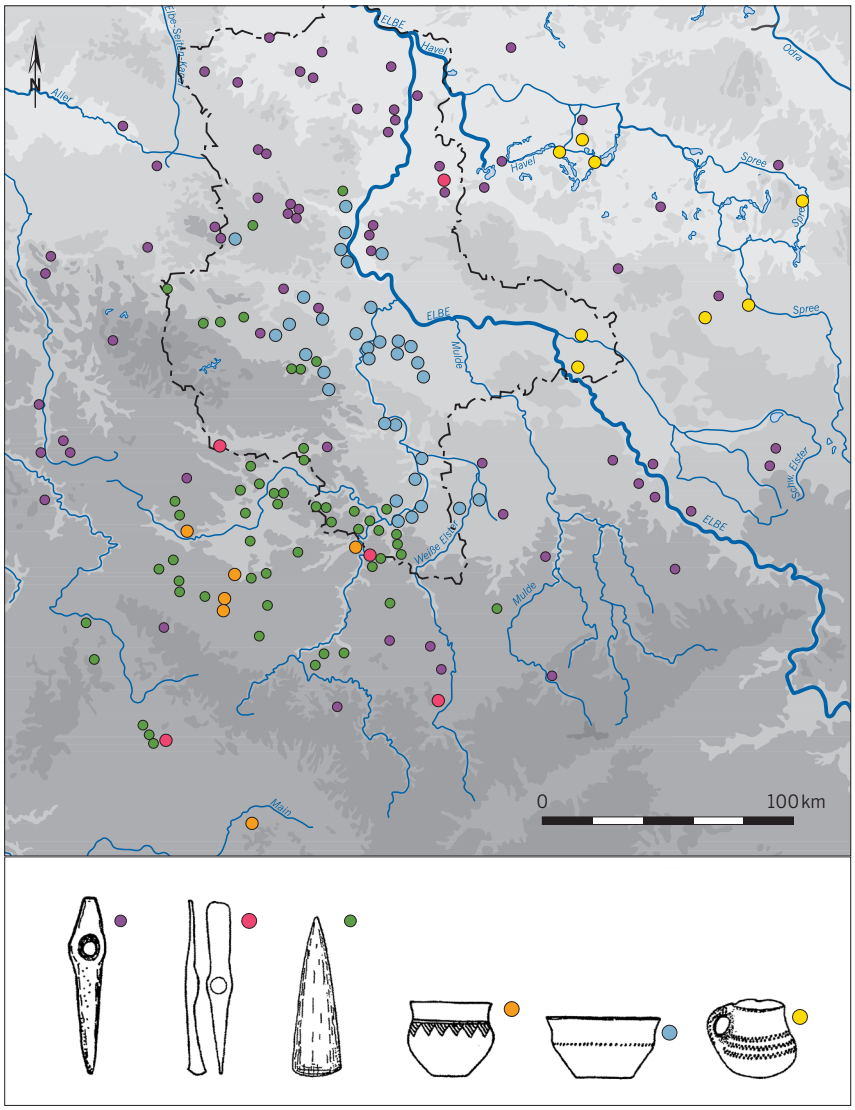


Abb. 5 Periphere Deponierungsareale oder andere Eigentümergruppen? Keramische Fundgruppen der Übergangsphase vom Mittel- zum Jungneolithikum im späten 5. Jt. v. Chr. in räumlicher Trennung von Fundpunkten steinerner und kupferner Großgeräte. Spitzhauen (lila), Jadeitbeile (grün), Kupferaxthacken (rot), Gruppen Schöningen-Schiepzig (blau), Bischheim (orange), Brześć Kujawski (gelb).

Fig. 5 *Peripheral deposition areas or different owner groups? Ceramic types of the transitional phase from the Middle to the Younger Neolithic Period in the late 5th millennium BC, spatially separated from find-spots of large stone and copper implements. Pickaxes (purple), jadeite axes (green), copper axe-adzes (red), groups Schöningen-Schiepzig (blue), Bischheim (orange), Brześć Kujawski (yellow).*

erhebungen und Überlegungen (Malmer 1962, 666–671; Beran 1990, 40–42; 192–194 Karten 6–8).

Irgendwann in der Mitte des 4. Jts. bricht aber dann offenbar in ganz Mittel- und Nordeuropa die typologische Entwicklung fortsetzungslos ab, enden Herstellung und wohl auch Bedeutung und Nutzung der Knaufhammeräxte und vielleicht auch der bis dahin noch – aus Sparsamkeit oder wegen ihres zunehmend ehrwürdigen Alters – aufbewahrten und benutzten Flachen Hammeräxte.

Ausgehend von rundnackigen Äxten südmitteleuropäischer Tradition beginnt nun die ganz neue Entwicklungsreihe der »doppelschneidigen Äxte« (Beran 2014a, 25 Abb. 4), die erst Jahrhunderte später mit den Nackenkammäxten der Kugelamphorenzeit endet.

Zeitlich fällt der Wechsel zwischen den beiden grundverschiedenen TBK-Axtformen zusammen mit der Grenze zwischen nordischem Früh- und Mittelneolithikum, mitteleuropäischem Jung- und Spätneolithikum, mit dem Aufkommen der reich verzierten Tiefstichkeramik und der megalithischen Ganggräber, mit verstärktem Ausgleich und zunehmenden Einflüssen zwischen Nordwesten und Südosten.

So ist dann möglicherweise in dieser sich in der archäologischen Überlieferung vielfach abzeichnenden gesellschaftlichen Umbruchzeit auch der ganze Bestand an Kultrequisiten und Feldzeichen geschlossen entsorgt und etwas ganz Neues angefangen worden. Vielleicht gab es so etwas wie einen überregionalen Friedensschluss? Wie ›das Ende der Geschichte‹ nach 1990? Die Symbole der alten Herrschaft und Ideologie wurden nicht wieder hervorgeholt bzw. bewusst, demonstrativ und eindeutig weggeworfen und einsedimentiert oder den Kindern zum Spielen und Kaputtmachen überlassen[8]. Ähnliche Vorgänge kennen wir aus der jüngeren Vergangenheit.

8 Zwei Fragmente Flacher Hammeräxte (Taf. 2,1.4) wurden in Potsdam-Nedlitz aus grabenartigen Befunden geborgen, die durch verzierte Scherben in die Waltersdorfer Gruppe der jüngeren östlichen Trichterbecherkultur datiert sind (Beran u. a. 2021). Die Axt von Potsdam Fpl. 14 (Abb. 2; Taf. 1.3) lag im oberen Teil der Grabeneinfüllung, sie dürfte auch erst am Ende der Nutzungszeit des frühneolithischen Erdwerkes hineingeraten sein (Beran/Kennecke 2019).

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Abbildungsnachweis

1 S. Schwarzländer, Brandenburgisches Landesamt für Denkmalpflege
2–3 Verf.
4 Beran 2011, 158 Abb. 3
5 Beran 2014, 10 Abb. 1
Taf. 1–10 Verf., außer 4,1; 5,2; 6,1.3–4: M. Rothe (†)

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Katalog einiger ausgewählter Streitaxtfunde

Im Folgenden wird die Gelegenheit wahrgenommen, zur weiteren Illustration der oben ausgeführten Gedanken sowie auch zur Komplettierung einige der überwiegend bereits vor vielen Jahren angefertigten Zeichnungen von Flachen Hammeräxten und auch Knaufhammeräxten bzw. unbestimmten und Übergangsformen aus Brandenburg, Mecklenburg-Vorpommern, Sachsen-Anhalt und Thüringen endlich einmal vorzulegen. Sie waren bisher entweder gar nicht oder in abweichender Darstellung oder Merkmalsinterpretation bzw. in unzureichender Reproduktionsqualität und ohne Einzel-Fundortangaben (Beran 1991, Abb. 2–3) publiziert worden. Deutlich werden hier z. B. die viel stärkere Fragmentierung im Süden und das Überwiegen unfertiger Stücke bei den Knaufhammeräxten, beginnend schon bei den Übergangsformen.

Brandenburg

(Taf. 1,4) Brieselang, Lkr. Havelland, Forstweg 9

Unvollendete und beschädigte Flache Hammeraxt. Archäologisches Landesmuseum Wünsdorf SK 2017:51/8/1/1 (Beran/Kennecke 2019, Abb. 24).

(Taf. 1,2) Fürstenwalde/Spree (?), Lkr. Oder-Spree

Gedrungene Flache Hammeraxt aus Porphyr, verwittert. Museum Fürstenwalde IV 926. Laut E. Kirsch Fundort unbekannt, nach Auskunft von J. Parschau, damals Museum Fürstenwalde, Fundort Fürstenwalde (Kirsch 1993, Abb. 85, Nr. 365; Kirsch 1994, Abb. 28,4).

(Taf. 1,1) Milow, Gem. Uckerland, Lkr. Uckermark

Typologisch jüngere Flache Hammeraxt mit bereits leichter Knaufbildung, Mittelgrat oben und unten, Bahnseiten scharf geknickt, mit unvollendetem doppelkonischem Schaftloch, aus grünlichem bis bräunlichem Porphyr mit bräunlichweißen Einsprenglingen und leichter, diabasartiger Nadelstruktur. Museum Waren IV/62/199 (Jahrb. Bodendenkmalpfl. Mecklenburg 1963, 307 Abb. 178; Nilius 1971, 129 Nr. 31, Typ Milow; Zápotocký 1992, 278 Nr. K 307, Taf. 53,1).

(Taf. 1,3) Potsdam Fpl. 14, Schiffbauergasse, Grabung 2003

Flache Hammeraxt mit Mittelrippe aus graugrünem Diabas (s. Abb. 2). Brandenburgisches Landesamt für Denkmalpflege und Archäologisches Landesmuseum (BLDAM) SK 2002-1603 (Beran/Hensel 2004, Abb. 31; Beran 2012, Abb. S. 43 Nr. 12; Beran/Kennecke 2019, Abb. 22).

(Taf. 2,1) Potsdam-Nedlitz, Konrad-Zuse-Ring, Grabung 2018

Finder A. Kurzhals. Aus Kulturschicht, wahrscheinlich Hausstelle innerhalb eines Erdwerkes. Schneidenhälfte einer Flachen Hammeraxt aus graugrünem, fein braunweiß gesprenkeltem Diabas. BLDAM SK 2018-568/416 (Beran/Richter 2020, 34 Abb. 28).

(Taf. 2,4) Potsdam-Nedlitz, Konrad-Zuse-Ring, Grabung M. Heller 2019

Als Einzelfund aus Schicht, eventuell Erdwerk, Nackenhälfte einer Flachen Hammeraxt aus Porphyr mit sehr groben Feldspateinsprenglingen. BLDAM SK 2019-64/144 (Beran u. a. 2021, 49 Abb. 41).

(Taf. 2,3) Rhinow, Lkr. Havelland

Aus einem nur teilweise erfassten flachen Befund (Hausgrube oder Graben möglich) Schneidenhälfte einer Flachen Hammeraxt aus graugrünem, fein dunkelgrau gesprenkeltem Diabas; zusammen mit zwei unspezifischen kleinen urgeschichtlichen Scherben, Grabung I. Beilke-Voigt, Finder A. Kurzhals, eintägige archäologische Baubegleitung am 24. 04. 2018, Bau eines Einfamilienhauses. Ein weiterer Grubenbefund mit Scherben neolithisch oder bronzezeitlich. BLDAM SK 2018-239/6/1.

(Taf. 2,2) Schneeberg, Stadt Beeskow, Lkr. Oder-Spree, Schneeberger Hauptfließ

Stark beschädigte Flache Hammeraxt, Schneide fehlt, aus graugrünem homogenem Diabas. Museum Beeskow IV 136 (Kirsch 1993, 75 Abb. 69, Nr. 270).

Mecklenburg-Vorpommern

(Taf. 6,3) Anklam, Lkr. Vorpommern-Greifswald

Baggerfund aus der Peene (?). Knaufhammeraxt mit von beiden Seiten begonnener Bohrung. Museum Waren IV/80/74 (Jahrb. Bodendenkmalpfl. Mecklenburg 1981, 328 Abb. 3b).

(Taf. 4,3) Bütow, Lkr. Mecklenburgische Seenplatte

Flache Hammeraxt aus graugrünem homogenem Gestein ohne Diabas-Nadelstruktur. Museum Waren 1953/33 (Nilius 1971, 119; Zápotocký 1992, 243 Nr. F 403).

(Taf. 5,2) Christinenhof, OT von Gielow, Lkr. Mecklenburgische Seenplatte, Fpl. 10, auf Lesesteinhaufen

Flache Hammeraxt, stark verwittert, Nacken stark beschädigt. Museum Waren IV 86/505 (Jahrb. Bodendenkmalpfl. Mecklenburg 1987 [1988], 321 Taf. 68d).

(Taf. 6,2) Dambeck, OT von Bütow, Lkr. Mecklenburgische Seenplatte, Fpl. 27

Knaufhammeraxt, undurchbohrt, mit stumpfer Schneide, aus hellgrünem, fein dunkelgrün gesprenkeltem Gestein, Oberfläche sorgfältig gepickt, nur auf beiden Bahnseiten je kleinere Fläche geschliffen. Museum Waren IV/79/568 (Jahrb. Bodendenkmalpfl. Mecklenburg 1980, 342 Abb. 13a).

(Taf. 3,1) Gotthun, Lkr. Mecklenburgische Seenplatte

Flache Hammeraxt aus graugrünem homogenem Diabas (?), die gezeichnete Unterseite mit mittiger Aufwölbung, die Oberseite ohne. Museum Waren IV/61/127 (Nilius 1971, 119; Jahrb. Bodendenkmalpfl. Mecklenburg 1961 [1962], 307 Abb. 201b; Zápotocký 1992, 243 Nr. F 414).

(Taf. 5,1) Groß Plasten, Lkr. Mecklenburgische Seenplatte

Typologisch frühe Knaufhammeraxt, Übergangsform von den Flachen Hammeräxten, aus schwarzgrauem Gestein mit großen orangen Einsprenglingen, Porphyr (?), beschädigt und verwittert. Museum Waren 58/24. (Jahrb. Bodendenkmalpfl. Mecklenburg 1958, 238 Abb. 164 c; Nilius 1971, 128 [als Knaufhammeraxt]; Zápotocký 1992, 277 Nr. K 291).

(Taf. 6,4) Grüttow, OT von Stolpe an der Peene, Lkr. Vorpommern-Greifswald

Knaufhammeraxt mit nur angedeuteter Bohrung und stumpfer Schneide. Museum Waren IV/63/259 (Nilius 1971, 128 Taf. 51k; Zápotocký 1992, 277 Nr. K 294).

(Taf. 4,1) Kittendorf, Lkr. Mecklenburgische Seenplatte

Flache Hammeraxt. Museum Waren IV/83/460.

(Taf. 3,2) Panschenhagen, Gem. Grabowhöfe, Lkr. Mecklenburgische Seenplatte

Flache Hammeraxt aus graugrünem homogenem Gestein, leicht verwittert. Museum Waren 4521 (Nilius 1971, 121).

(Taf. 5,4) Plöwen, Lkr. Vorpommern-Greifswald, Fpl. 23, auf Lesesteinhaufen

Nackenhälfte einer Knaufhammeraxt mit unvollendeter, doppelkonischer Bohrung aus graugrün homogenem Gestein, Oberfläche gepickt. Museum Waren IV/72/134 (Kirsch 1993, 126 Abb. 101, Nr. 505).

(Taf. 5,3) Rossow, Lkr. Vorpommern-Greifswald, Fpl. 18

Bruchstück, reduzierte Nackenhälfte, einer typologisch späten Flachen Hammeraxt (ähnlich Milow), aus schwarzgrauem Gestein mit rötlichen Einsprenglingen, Nacken stark abgeklopft. Museum Waren IV/64/594 (Jahrb. Bodendenkmalpfl. Mecklenburg 1964 [1965], 382; Nilius 1971, 121; Zápotocký 1992, 245 Nr. F 461; Kirsch 1993, 127 f. Abb. 101, Nr. 521).

(Taf. 6,1) Strippow, OT von Neuenkirchen bei Anklam, Lkr. Vorpommern-Greifswald, Fpl. 2

Knaufhammeraxt mit begonnener Bohrung. Museum Waren IV/81/411 (Jahrb. Bodendenkmalpfl. Mecklenburg 1983, 530 Abb. 15c).

(Taf. 3,3) Waren (Müritz), Lkr. Mecklenburgische Seenplatte

Flache Hammeraxt aus braungrauem Gestein mit Diabas-Nadelstruktur, Schaftlochverstärkungen leicht abgeplattet. Museum Waren 4667 (Nilius 1971, 121).

(Taf. 4,2) Zepkow, Gem. Eldetal, Lkr. Mecklenburgische Seenplatte

Große Flache Hammeraxt aus graugrünem homogenem Gestein mit nur ganz vereinzelten grünlichweißen Einsprenglingen, exakt gearbeitet, nicht verwittert. Museum Waren IV/71/379 (Schuldt 1968, Abb. 2; Nilius 1971, 122; Zápotocký 1992, 247 F 486).

Sachsen-Anhalt

(Taf. 7,2) Helmsdorf, Stadt Gerbstedt, Lkr. Mansfeld-Südharz, Wüstung Nienstedt, »von einem alten und hohen Scherbelberg«

Flache Hammeraxt aus hellgrünem, fein dunkelgrün gesprenkeltem Diabas, Seitenflächen gerundet, Schaftlochverstärkungen spitz, zylindrisches Schaftloch Dm 2,4 cm. Museum Eisleben 1010.

(Taf. 7,3) Oberschmon, OT von Schmon, Stadt Querfurt, Saalekreis

Schneidenhälfte wohl eher einer Knaufhammeraxt aus porphyrartigem Gestein mit vielen kleinen rötlichen Feldspateinsprenglingen, Schneide stumpf geschliffen, Seiten flach geschliffen, Rille nur auf Unterseite, setzt kurz vor dem Schaftloch aus. Museum Jena 14867 (Berlekamp 1963, 191; Zápotocký 1992, 239 F 331).

(Taf. 7,1) Spielberg, OT von Grockstädt, Stadt Querfurt, Saalekreis, »auf dem Berge«, östlich des Dorfes gefunden im Frühjahr 1921

Nackenhälfte einer Flachen Hammeraxt aus bräunlich graugrünem homogenem Gestein, Grate auf Oberseite flach geschliffen. Museum Weimar, ehem. Sammlung Limpert, Neunheilingen, Nr. 1.

(Taf. 7,4) Fundort unbekannt, wohl Nordharzgebiet

Schneidenhälfte einer Flachen Hammeraxt, sekundär durchbohrt, stark verwittert. Museum Wernigerode IV 925.

Thüringen

(Taf. 8,2) Bachra, Stadt Rastenberg, Lkr. Sömmerda, »Unter dem Weinberg«

Eingeliefert 20.08.1969. Schneidenhälfte eher einer Knaufhammeraxt als einer Flachen Hammeraxt aus bräunlich graugrünem, homogenem Sedimentgestein oder Basalt, Rillen auf Lochseiten schwach erkennbar. Museum Weimar 1574/69.

(Taf. 10,3) Gräfentonna, Gem. Tonna, Lkr. Gotha, Lohberg

Nackenhälfte einer Flachen Hammeraxt aus graugrünem Gestein, verwittert. Museum Weimar L. G. 1873.

(Taf. 9,5) Heringen/Helme, Lkr. Nordhausen

Rest von Schneidenhälfte vielleicht einer Knaufhammeraxt aus schwarzgrauem, glimmerhaltigem, schiefrigem Gestein, beidseitig konisch sekundär angebohrt. Museum Weimar 563/85.

(Taf. 9,4) Hirschroda, Stadt Dornburg-Camburg, Saale-Holzland-Kreis

Nackenhälfte einer Flachen Hammeraxt aus weißlich grünem, unregelmäßig dunkelgrün marmoriertem Gestein (wie Lachstedt Nr. 25709), Grat auf Oberseite flach geschliffen. Museum Jena 14086.

(Taf. 8,6) Ichtershausen, Gem. Amt Wachsenburg, Ilm-Kreis, Siedlung Petersberg

Fragment von der hinteren Oberseite einer Flachen Hammeraxt oder Knaufhammeraxt aus graugrün-gelbgrün sehr fein gesprenkeltem Gestein. Museum Weimar 1049/85.

(Taf. 8,4) Krippendorf, Stadt Jena

Fragment von Nackenhälfte eher einer Knaufhammeraxt als einer Flachen Hammeraxt aus dunkel bräunlich graugrünem Gestein. Museum Jena 30404.

(Taf. 8,3) Krippendorf, Stadt Jena

Nackenhälfte einer kleinen Flachen Hammeraxt aus graugrünem, schiefrig gemasertem Gestein. Museum Jena 30404.

(Taf. 8,1) Lachstedt (?), Gem. Schmiedehausen, Lkr. Weimarer Land

Stark verwitterte Schneidenhälfte einer Flachen Hammeraxt aus graugrünem schiefrigem Gestein. Museum Jena 26984.

(Taf. 8,5) Lachstedt, Gem. Schmiedehausen, Lkr. Weimarer Land

Rest von Nackenhälfte wohl eher einer Knaufhammeraxt, beschädigter bzw. abgebrochener Nacken stark überschliffen, aus weißlichgrünem, leicht schwarz marmoriertem Gestein, Schaftloch leicht doppelkonisch. Museum Jena 25709 (Zápotocký 1992, 238 Nr. F 312, Taf. 11,6 als schneidenseitiges Fragment einer Flachen Hammeraxt).

(Taf. 9,1) Oberbösa, Kyffhäuserkreis »Rohmborn«, Rehmstraße

Wohl Nackenhälfte einer Flachen Hammeraxt aus dunkel-graugrünem, homogenem, relativ hartem und dichtem Gestein. Museum Weimar 168/60 (Müller 1975, 151 f. Abb. 6,1 als Schneidenhälfte einer Flachen Hammeraxt; Zápotocký 1992, 239 Nr. F 328).

(Taf. 10,1) Reisdorf, Stadt Bad Sulza, Lkr. Weimarer Land, Fundplatz unbekannt

Schneidenhälfte einer Flachen Hammeraxt aus schwarzem, unregelmäßig bräunlichweiß gesprenkeltem Gestein, seitliche Bruchfläche sekundär überschliffen. Museum Weimar 2273/83, ehemalige Sammlung Reiß.

(Taf. 9,6) Schafau, Stadt Rastenberg, Lkr. Sömmerda

Schneidenhälfte wohl einer Knaufhammeraxt aus graugrünem, schiefrigem Gestein, stark verwittert. Museum Weimar 4850.

(Taf. 9,2) Schkölen, Saale-Holzland-Kreis

Nackenhälfte einer Flachen Hammeraxt aus ganz fein dunkelgraugraugrün gemasertem Gestein. Museum Jena 13832 (Loewe 1959, 122 Taf. 98,4; Berlekamp 1963, 192; Zápotocký 1992, 239 Nr. F 342).

(Taf. 9,3) Schlotheim, Unstrut-Hainich-Kreis

Nackenhälfte einer Flachen Hammeraxt aus schwarzem, homogenem Gestein. Museum Mühlhausen K1/226 und III/28/7.

(Taf. 10,2) Schlotheim, Unstrut-Hainich-Kreis

Nackenhälfte einer großen Flachen Hammeraxt vom in Längsrichtung leicht gebogenen, gratverzierten süddeutsch-schweizerischen Typ aus dunkelgrauem, hellbraun gesprenkeltem Gestein. Museum Weimar 8529, ehemals Mus. Halberstadt 3229 (Zápotocký 1992, 239 F 343, Taf. 11,4).

(Taf. 10,6) Weimar, Ettersberg

Nackenhälftenbruchstück einer Flachen Hammeraxt aus graugrünem schiefrigem Gestein, stark verwittert. Museum Weimar H 1324.

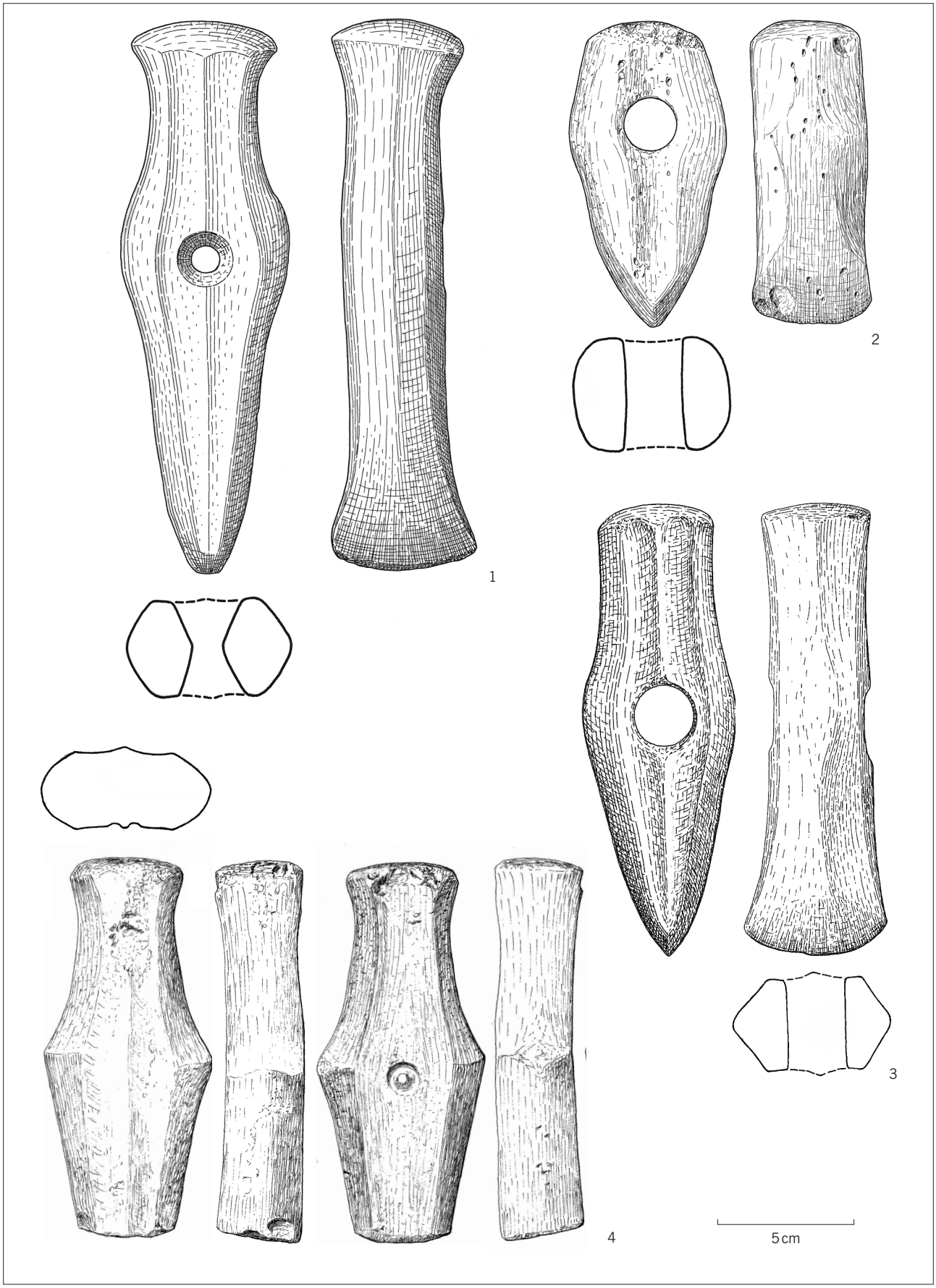
(Taf. 10,5) Weimar, Ettersberg

Nackenhälfte einer Flachen Hammeraxt aus hell graugrünem homogenem, relativ weichem Gestein, vielleicht Diabas. Museum Weimar H 1325.

(Taf. 10,4) Westgreußen, Kyffhäuserkreis

Nackenhälfte, schräg gebrochen, einer Flachen Hammeraxt mit leichter Knaufbildung, aus schwarz glänzendem, hartem, dichtem, glimmerhaltigem Gestein. Mueum. Weimar 1523/75.

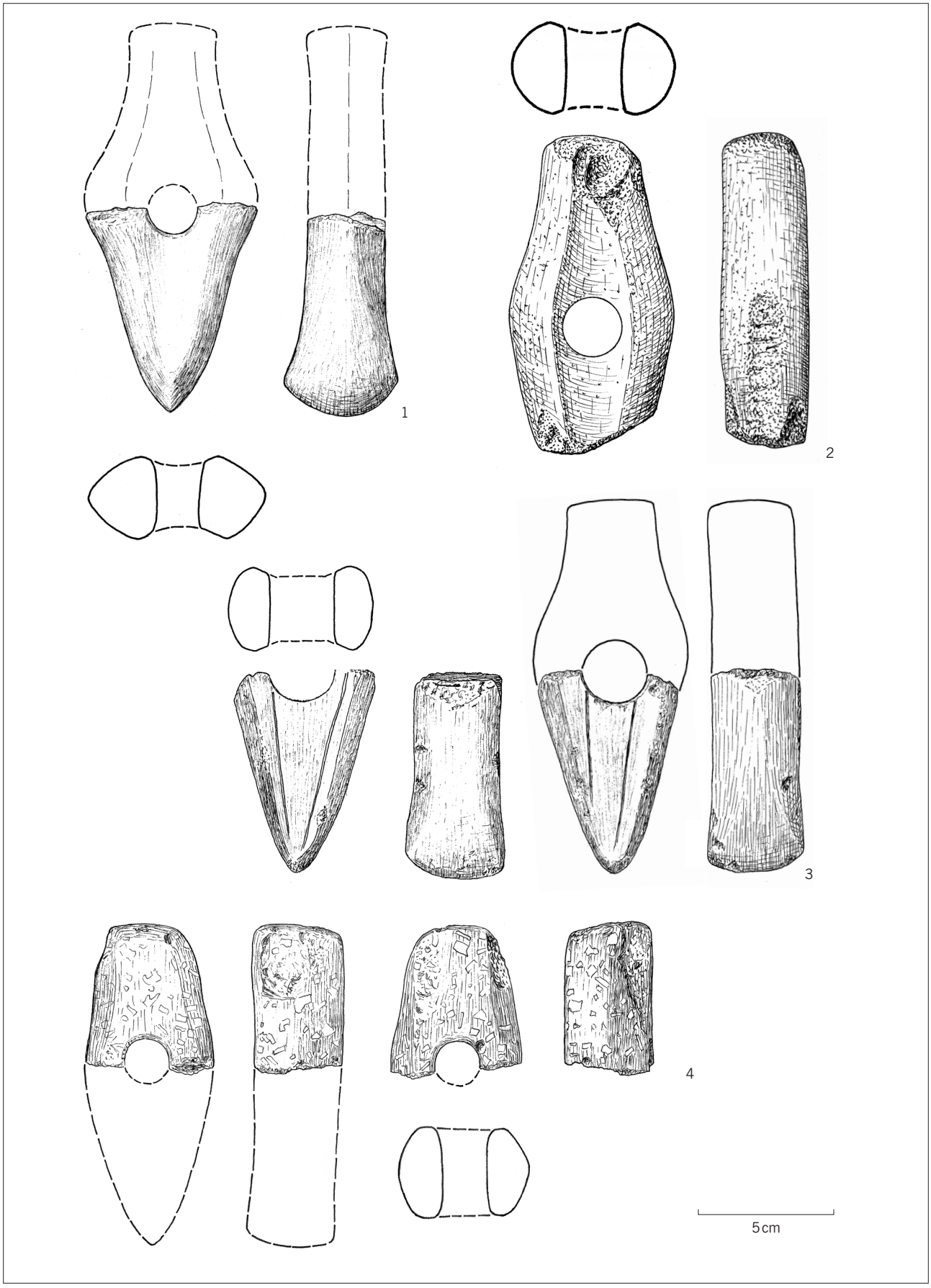
Tafel 1



Taf. 1 Flache Hammeräxte aus Brandenburg. 1 Milow, Gem. Uckerland, Lkr. Uckermark; 2 Fürstenwalde/Spree (?), Lkr. Oder-Spree; 3 Potsdam, Fpl. 14, Schiffbauergasse, Grabung 2003; 4 Brieselang, Lkr. Havelland, Forstweg 6.

Pl. 1 *Flat hammer-axes from Brandenburg. 1 Milow, municipality of Uckerland, Uckermark district; 2 Fürstenwalde/Spree (?), Oder-Spree district; 3 Potsdam, find-spot 14, Schiffbauergasse, excavation 2003; 4 Brieselang, Havelland district, Forstweg 6.*

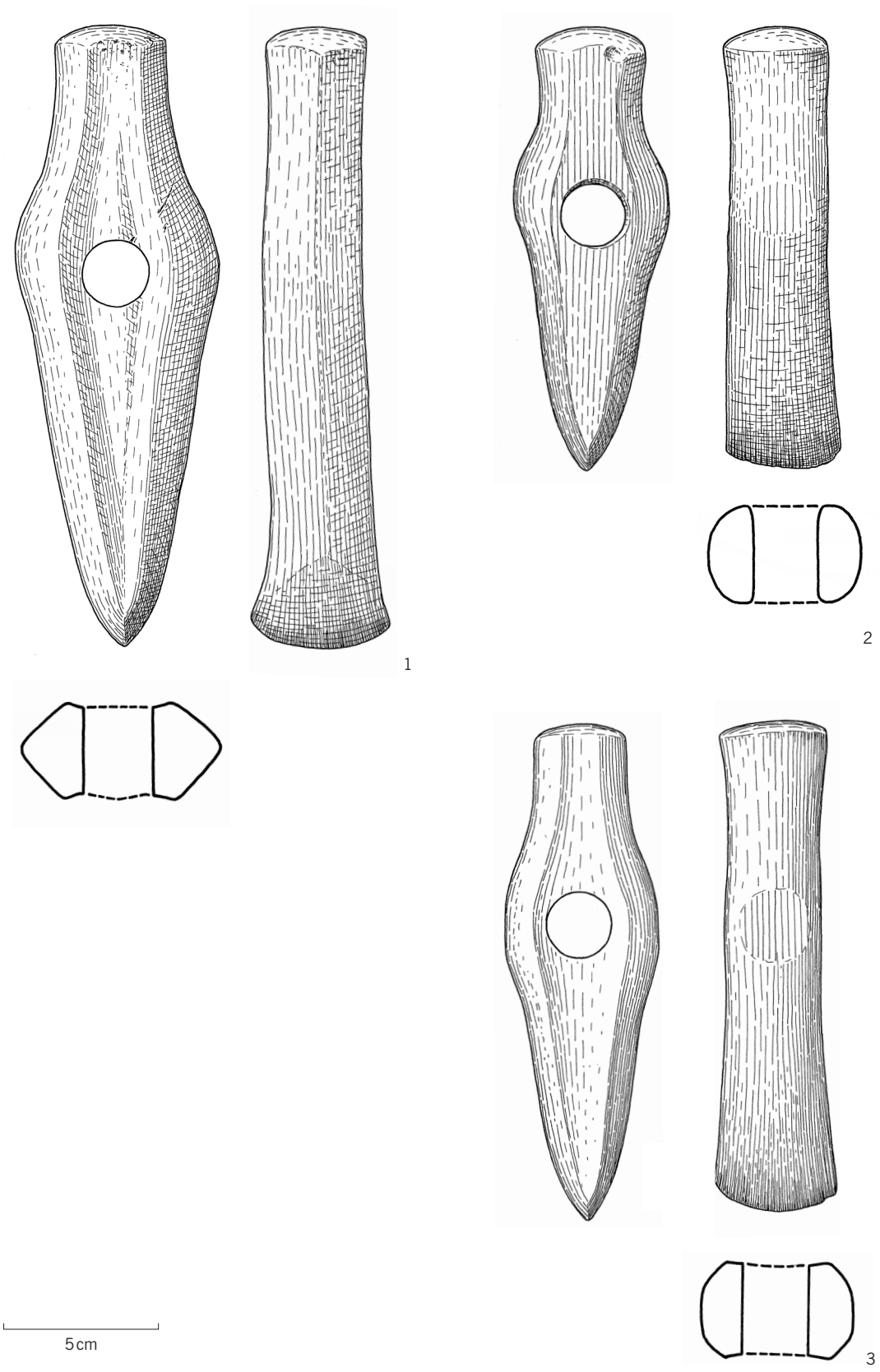
Tafel 2



Taf. 2 Flache Hammeräxte aus Brandenburg. 1 Potsdam-Nedlitz, Konrad-Zuse-Ring, Grabung 2018; 2 Schneeberg, Stadt Beeskow, Lkr. Oder-Spree; 3 Rhinow, Lkr. Havelland; 4 Potsdam-Nedlitz, Konrad-Zuse-Ring, Grabung 2019.

Pl. 2 *Flat hammer-axes from Brandenburg. 1 Potsdam-Nedlitz, Konrad-Zuse-Ring, excavation 2018; 2 Schneeberg, town of Beeskow, Oder-Spree district; 3 Rhinow, Havelland district; 4 Potsdam-Nedlitz, Konrad-Zuse-Ring, excavation 2019.*

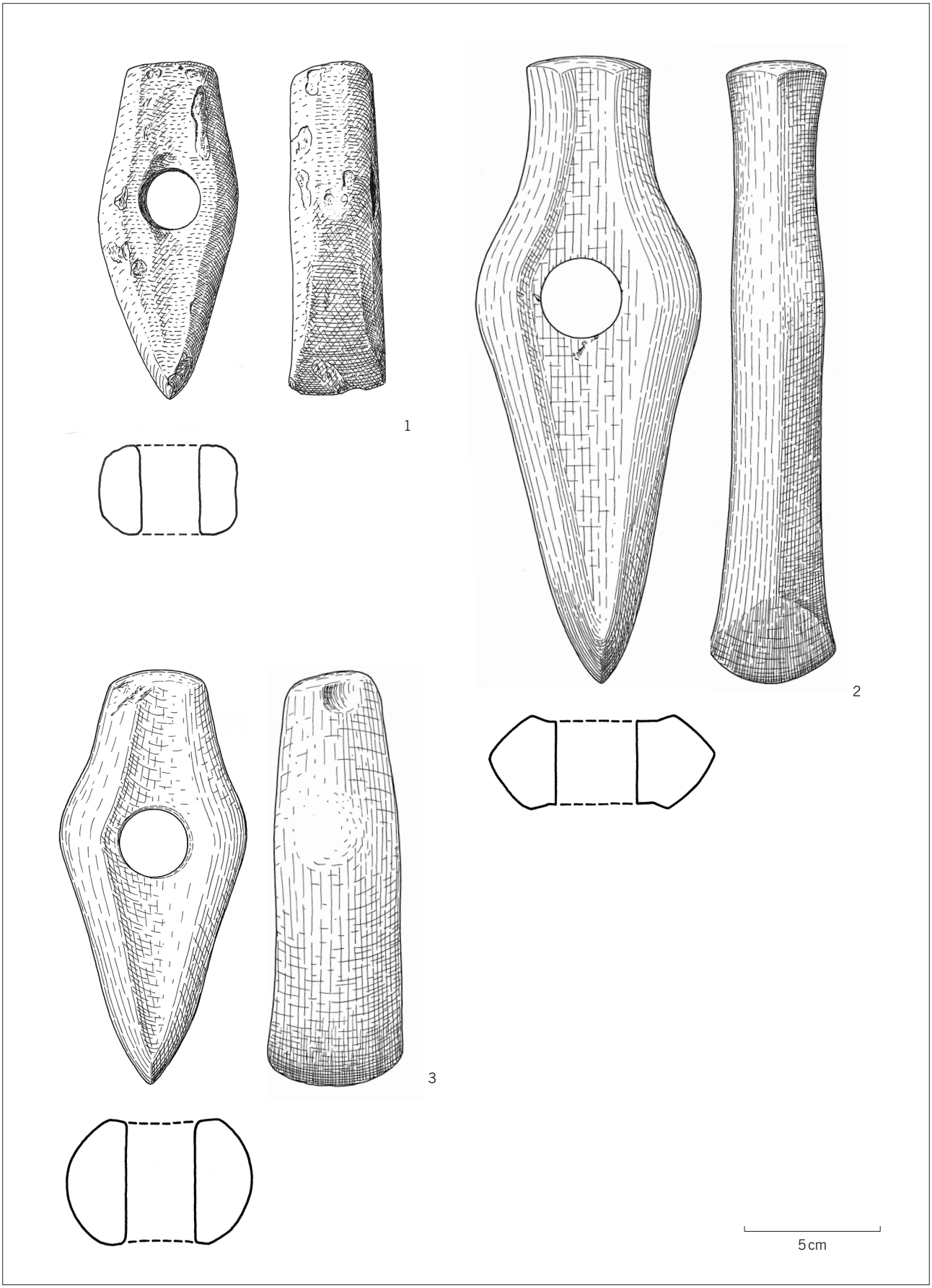
Tafel 3



Taf. 3 Flache Hammeräxte aus Mecklenburg-Vorpommern. 1 Gotthun, Lkr. Mecklenburgische Seenplatte; 2 Panschenhagen, Gem. Grabowhöfe, Lkr. Mecklenburgische Seenplatte; 3 Waren (Müritz), Lkr. Mecklenburgische Seenplatte.

Pl. 3 *Flat hammer-axes from Mecklenburg-Western Pomerania. 1 Gotthun, Mecklenburg Lake district; 2 Panschenhagen, municipality of Grabowhöfe, Mecklenburgische Seenplatte district; 3 Waren (Müritz), Mecklenburgische Seenplatte district.*

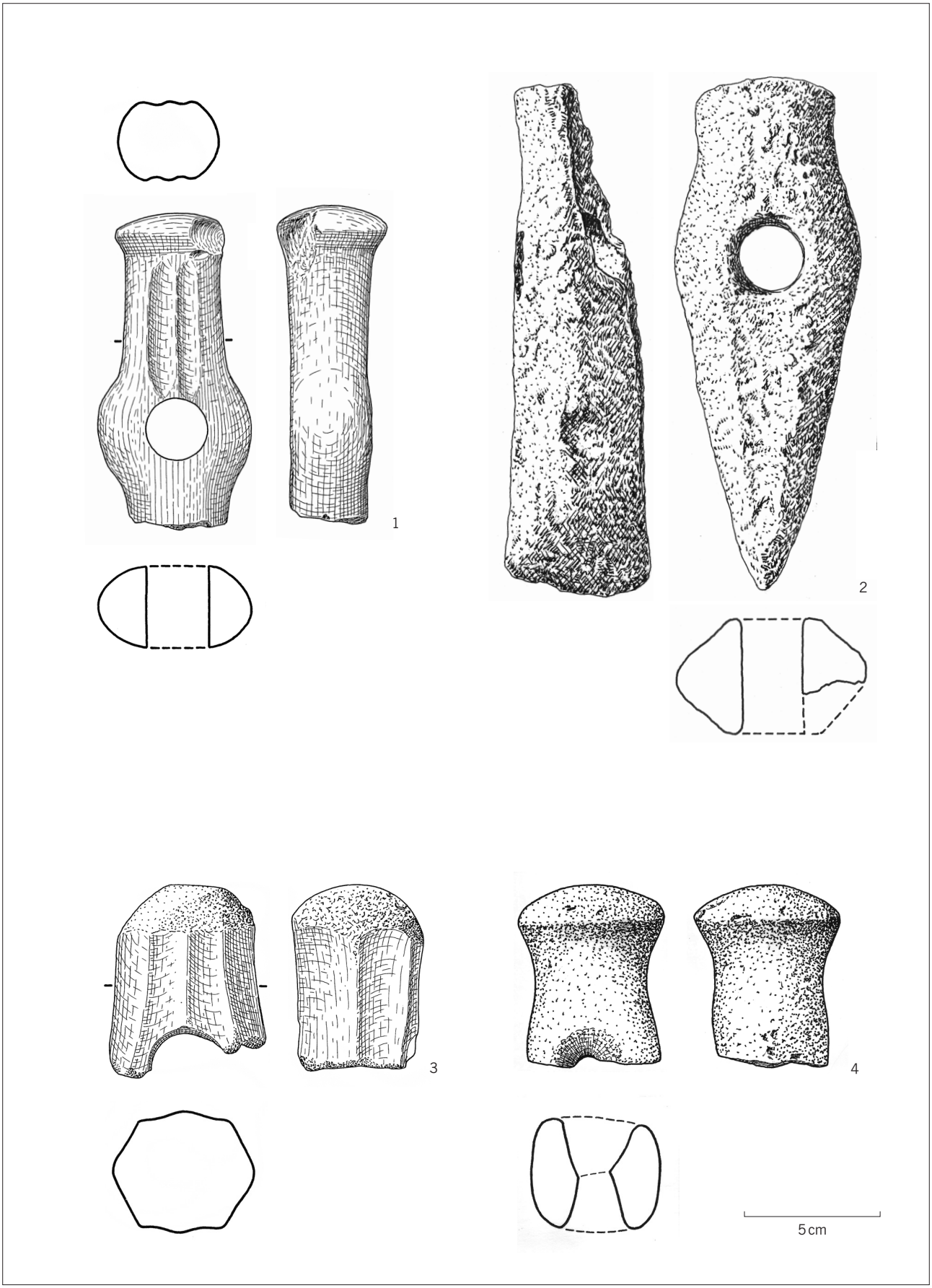
Tafel 4



Taf. 4 Flache Hammeräxte aus Mecklenburg-Vorpommern. 1 Kittendorf, Lkr. Mecklenburgische Seenplatte; 2 Zepkow, Gem. Eldetal, Lkr. Mecklenburgische Seenplatte; 3 Bütow, Lkr. Mecklenburgische Seenplatte.

Pl. 4 *Flat hammer-axes from Mecklenburg-Western Pomerania. 1 Kittendorf, Mecklenburgische Seenplatte district; 2 Zepkow, municipality of Eldetal, Mecklenburgische Seenplatte district; 3 Bütow, Mecklenburgische Seenplatte district.*

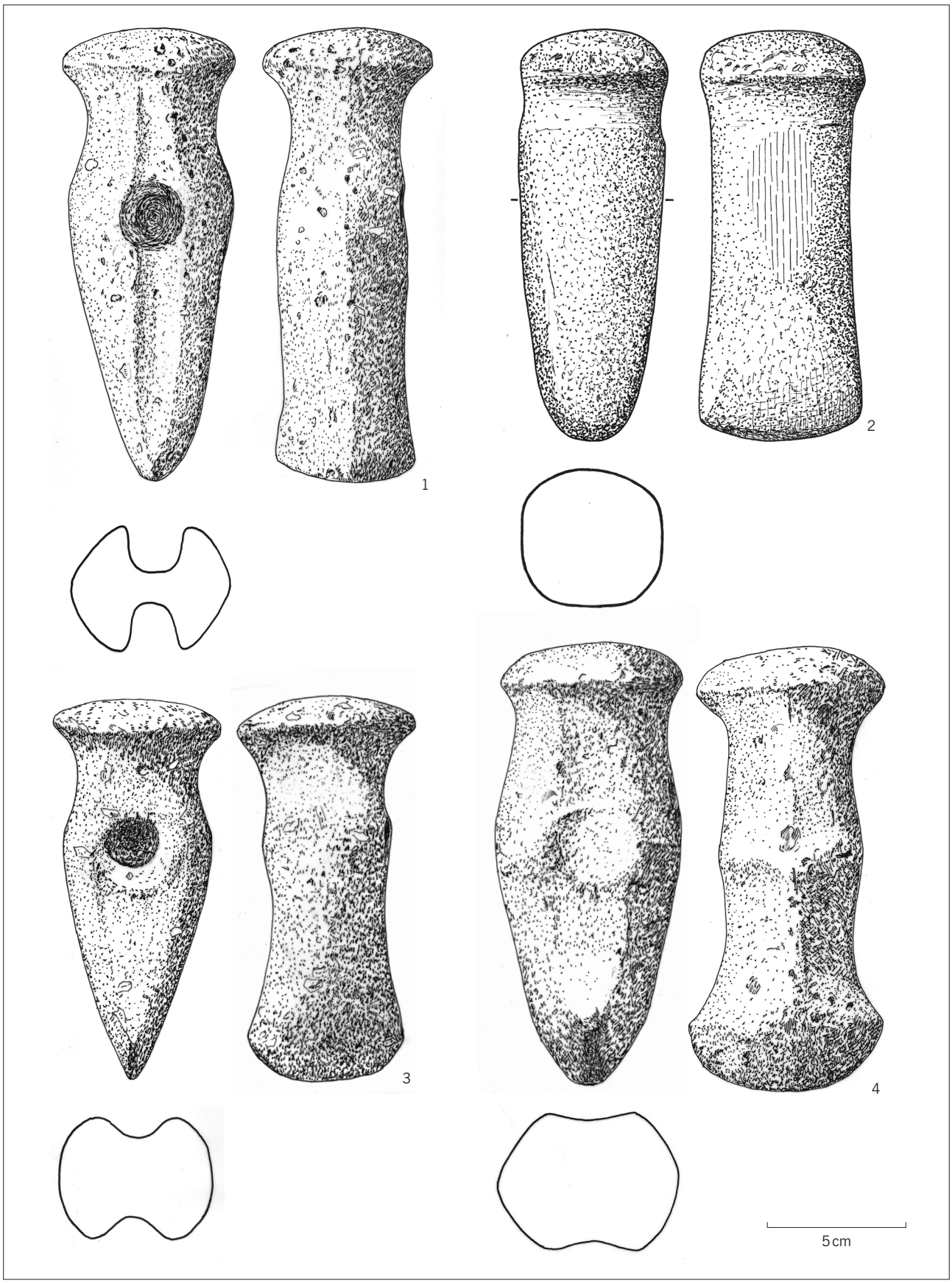
Tafel 5



Taf. 5 Flache Hammeräxte und Knaufhammeräxte aus Mecklenburg-Vorpommern. 1 Groß Plasten, Lkr. Mecklenburgische Seenplatte; 2 Christinenhof, OT von Gielow, Lkr. Mecklenburgische Seenplatte; 3 Rossow, Lkr. Vorpommern-Greifswald; 4 Plöwen, Lkr. Vorpommern-Greifswald.

Pl. 5 *Flat hammer-axes and knob-butted hammer-axes from Mecklenburg-Western Pomerania. 1 Groß Plasten, Mecklenburgische Seenplatte district; 2 Christinenhof, part of Gielow, Mecklenburgische Seenplatte district; 3 Rossow, Vorpommern-Greifswald district; 4 Plöwen, Vorpommern-Greifswald district.*

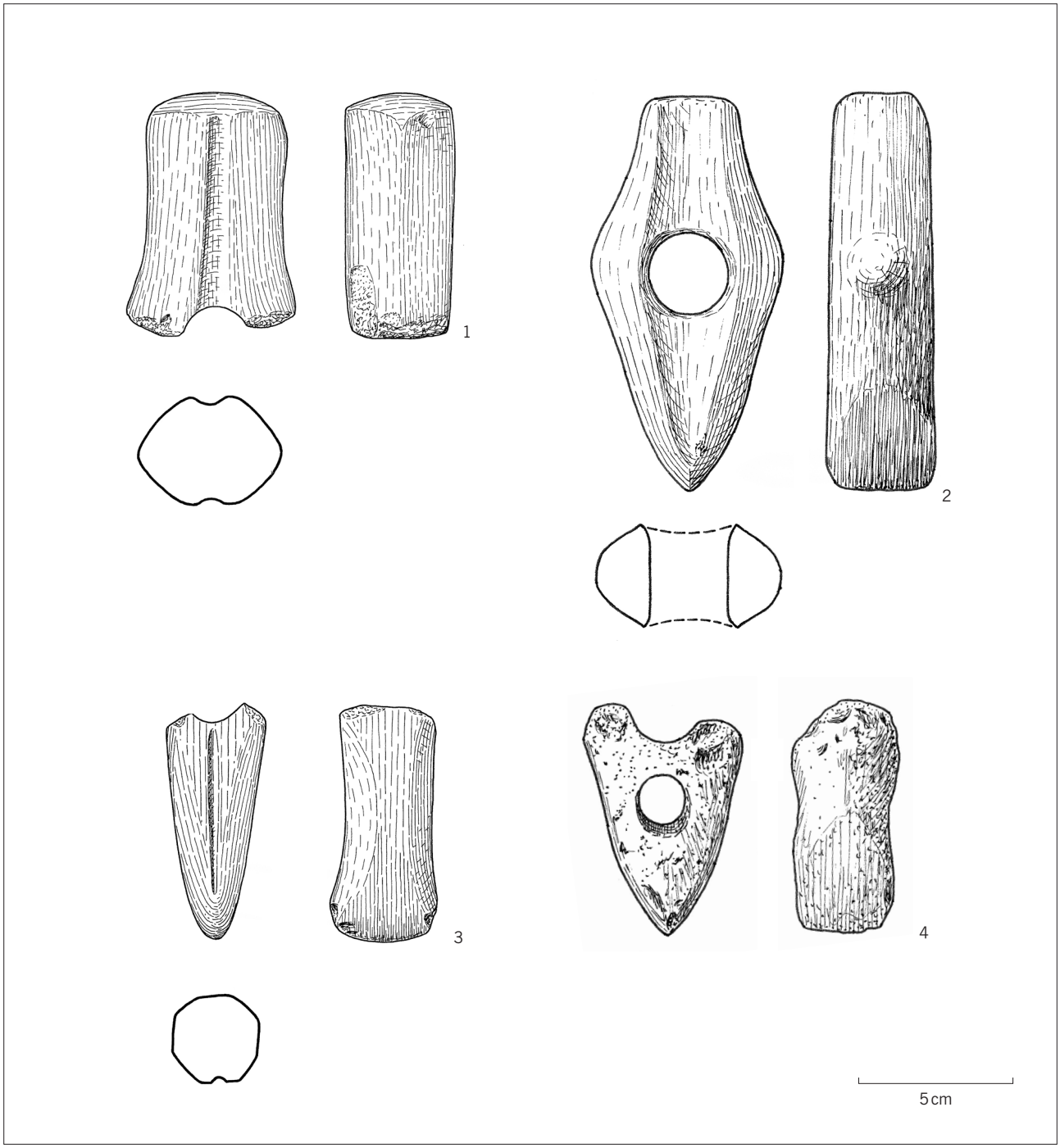
Tafel 6



Taf. 6 Unvollendete Knaufhammeräxte aus Mecklenburg-Vorpommern. 1 Strippow, OT von Neuenkirchen (bei Anklam), Lkr. Vorpommern-Greifswald; 2 Dambeck, OT von Bütow, Lkr. Mecklenburgische Seenplatte; 3 Anklam, Lkr. Vorpommern-Greifswald; 4 Grüttow, OT von Stolpe an der Peene, Lkr. Vorpommern-Greifswald.

Pl. 6 *Unfinished knob-butted hammer-axes from Mecklenburg-Western Pomerania. 1 Strippow, part of Neuenkirchen (near Anklam), Vorpommern-Greifswald district; 2 Dambeck, part of Bütow, Mecklenburgische Seenplatte district; 3 Anklam, Vorpommern-Greifswald district; 4 Grüttow, part of Stolpe an der Peene, Vorpommern-Greifswald district.*

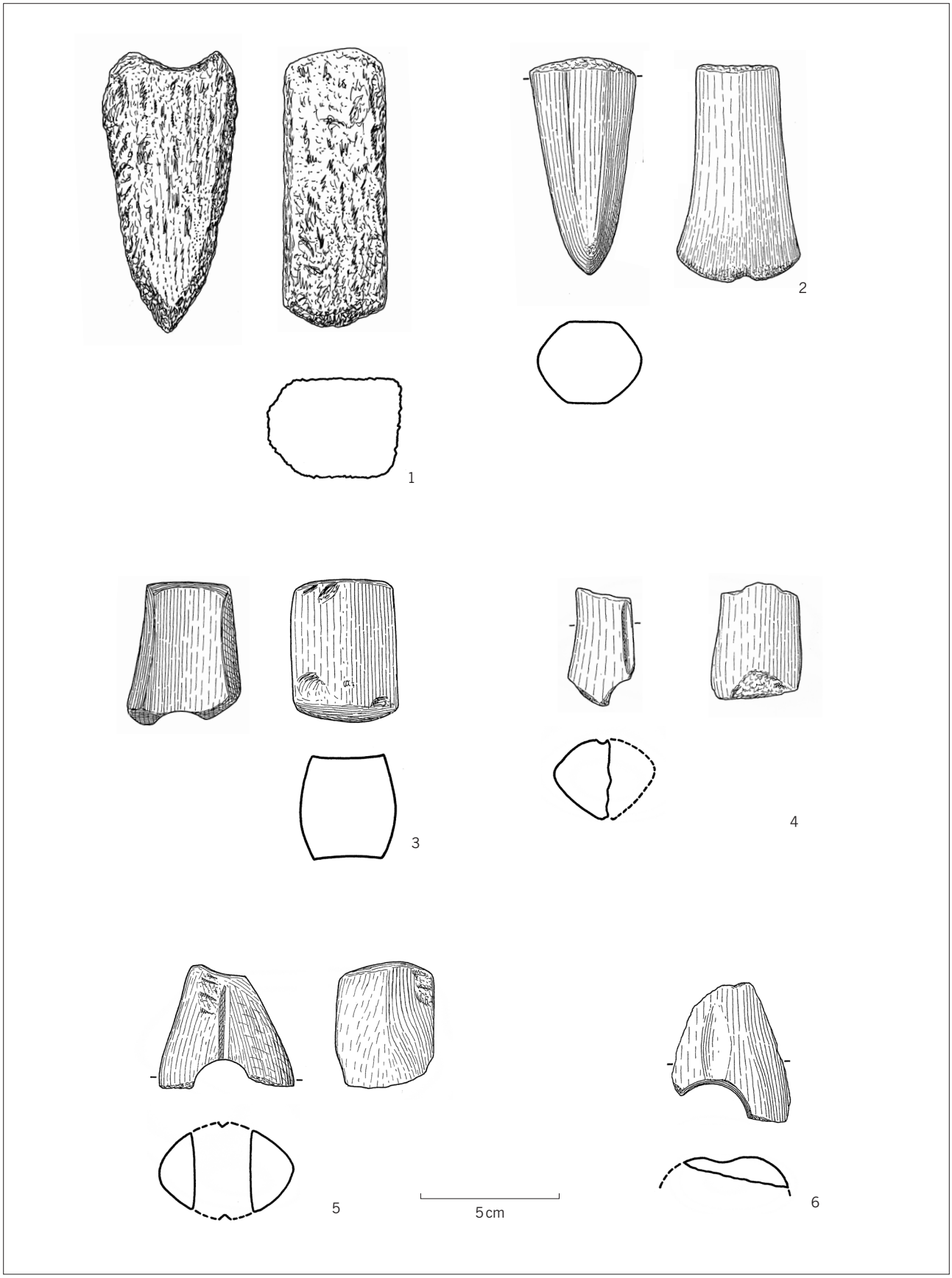
Tafel 7



Taf. 7 Flache Hammeraxt und Axtfragmente aus Sachsen-Anhalt. 1 Spielberg, OT von Grockstädt, Stadt Querfurt, Saalekreis; 2 Helmsdorf, Stadt Gerbstedt, Lkr. Mansfeld-Südharz; 3 Oberschmon, OT von Schmon, Stadt Querfurt, Saalekreis; 4 Fundort unbekannt, Museum Wernigerode.

Pl. 7 *Flat hammer-axes and axe fragments from Saxony-Anhalt. 1 Spielberg, part of Grockstädt, town of Querfurt, Saalekreis district; 2 Helmsdorf, town of Gerbstedt, Mansfeld-Südharz district; 3 Oberschmon, part of Schmon, town of Querfurt, Saalekreis district; 4 find-spot unknown, Museum Wernigerode.*

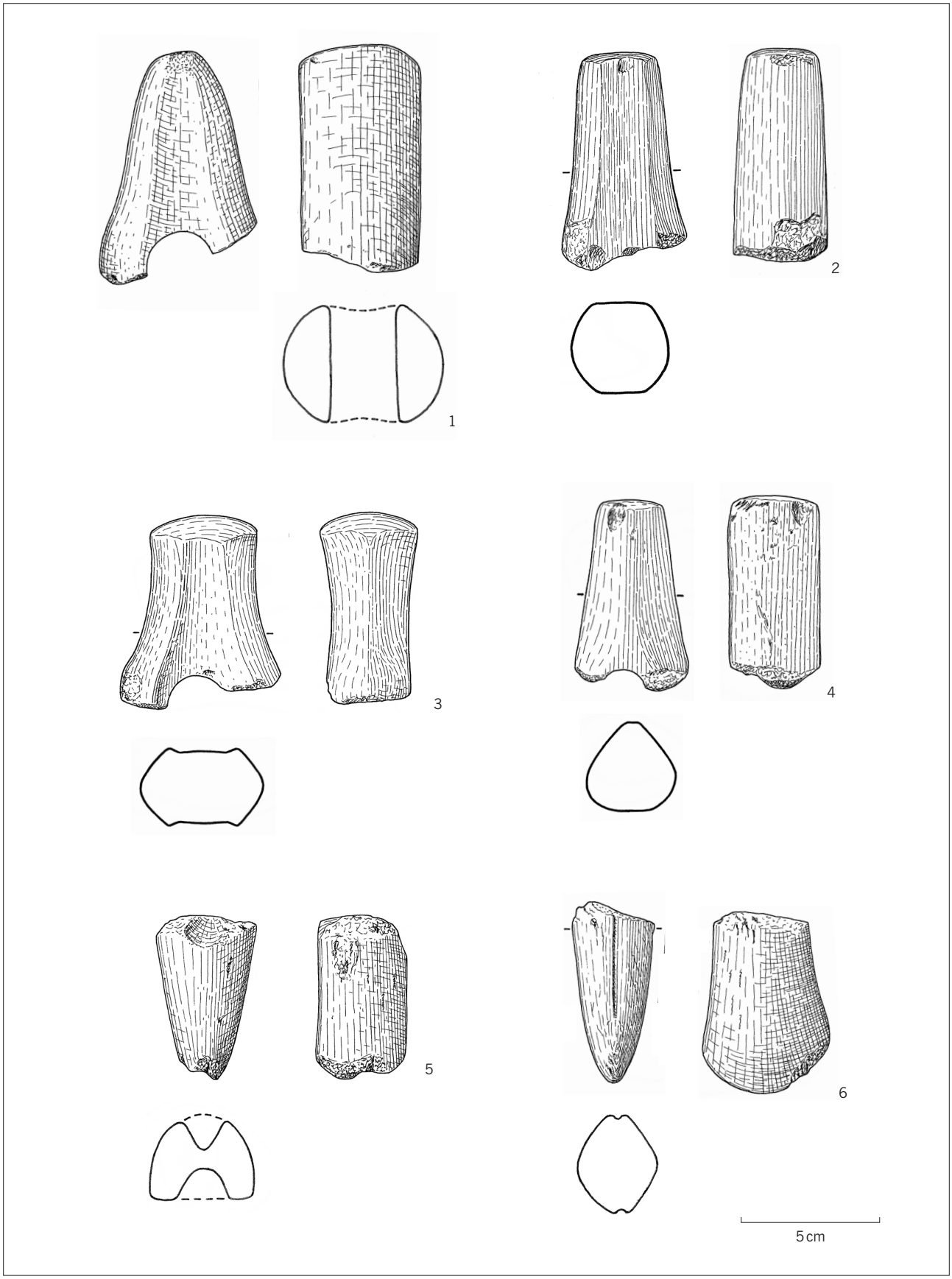
Tafel 8



Taf. 8 Fragmente von Flachen Hammeräxten und Knaufhammeräxten aus Thüringen. 1 Lachstedt (?), Gem. Schmiedehausen, Lkr. Weimarer Land; 2 Bachra, Stadt Rastenberg, Lkr. Sömmerda; 3–4 Krippendorf, Stadt Jena; 5 Lachstedt, Gem. Schmiedehausen, Lkr. Weimarer Land; 6 Ichtershausen, Gem. Amt Wachsenburg, Ilm-Kreis.

Pl. 8 *Fragments of flat hammer-axes and knob-butted hammer-axes from Thuringia. 1 Lachstedt (?), municipality of Schmiedehausen, Weimarer Land district; 2 Bachra, town of Rastenberg, Sömmerda district; 3–4 Krippendorf, town of Jena; 5 Lachstedt, municipality of Schmiedehausen, Weimarer Land district; 6 Ichtershausen, municipality of Amt Wachsenburg, Ilm district.*

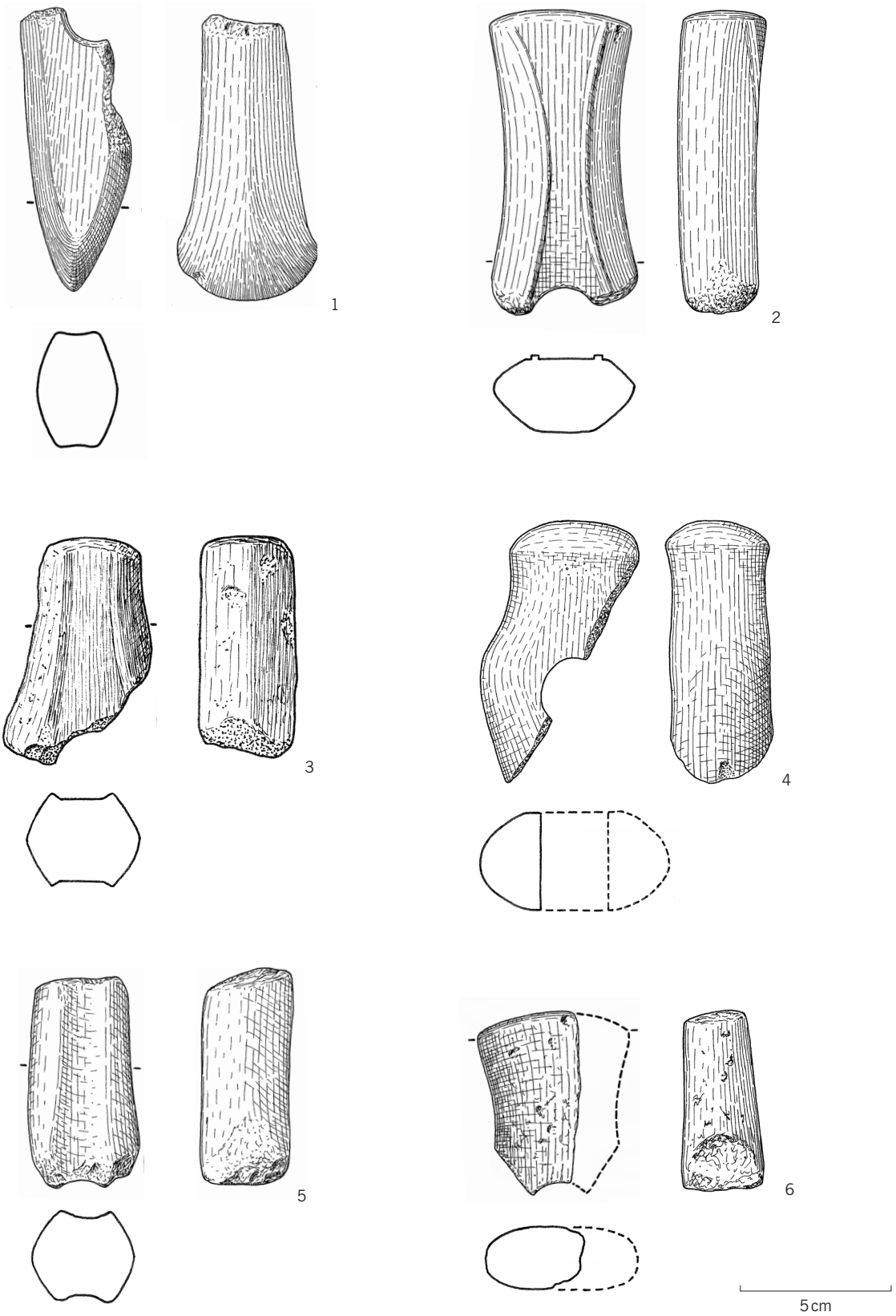
Tafel 9



Taf. 9 Fragmente von Flachen Hammeräxten und Knaufhammeräxten aus Thüringen. 1 Oberbösa, Kyffhäuserkreis; 2 Schkölen, Saale-Holzland-Kreis; 3 Schlotheim, Unstrut-Hainich-Kreis; 4 Hirschroda, Stadt Dornburg-Camburg, Saale-Holzland-Kreis; 5 Heringen/Helme, Lkr. Nordhausen; 6 Schafau, Stadt Rastenberg, Lkr. Sömmerda.

Pl. 9 *Fragments of flat hammer-axes and knob-butted hammer-axes from Thuringia. 1 Oberbösa, Kyffhäuser district; 2 Schkölen, Saale-Holzland district; 3 Schlotheim, Unstrut-Hainich district; 4 Hirschroda, town of Dornburg-Camburg, Saale-Holzland district; 5 Heringen/Helme, Nordhausen district; 6 Schafau, town of Rastenberg, Sömmerda district.*

Tafel 10



Taf. 10 Fragmente von Flachen Hammeräxten und Knaufhammeräxten aus Thüringen. 1 Reisdorf, Stadt Bad Sulza, Lkr. Weimarer Land; 2 Schlotheim, Unstrut-Hainich-Kreis; 3 Gräfentonna, Gem. Tonna, Lkr. Gotha; 4 Westgreußen, Kyffhäuserkreis; 5–6 Weimar, Ettersberg.

Pl. 10 *Fragments of flat hammer-axes and knob-butted hammer-axes from Thuringia. 1 Reisdorf, town of Bad Sulza, Weimarer Land district; 2 Schlotheim, Unstrut-Hainich district; 3 Gräfentonna, municipality of Tonna, Gotha district; 4 Westgreußen, Kyffhäuser district; 5–6 Weimar, Ettersberg.*

Flintbeile im Hochglanzformat – Machtsymbole der Kugelamphorenkultur

Jonas Beran, Jochen Fahr und Susanne Friederich

Summary

High-gloss flint axes – The Globular Amphora Culture's symbols of power

Only very few settlements of the transregional Globular Amphora Culture are known in Saxony-Anhalt. Inhumations – individual, in small groups, or accompanied by animal depositions – are, however, discovered frequently. Particularly the intentional killing of cattle for a deceased and the deposition of cattle in pairs reveal a certain prosperity but are also proof of a patriarchally structured society where a few men accumulated power and wealth. The following grave goods of higher quality stand out: jewellery, elaborately decorated vessels, and, above all, tools – mainly axes made of flint. No matter their size, they are always carefully shaped, ground, and usually polished to a high sheen. The transregional trade initiated by individual specialists or even artisan centres must have facilitated the broad distribution of these luxury items, as was the case with amber jewellery. Is it possible that the valuable flint axes of the Globular Amphora Culture were no individual possession, in contrast to the masses of shaft-hole ground stone axes used as grave goods in the subsequent Corded Ware Culture.

Keywords Globular Amphora Culture, flint axes, symbols of power, elite burials, landscape archaeology

Zusammenfassung

Von der überregional verbreiteten Kugelamphorenkultur sind aus Sachsen-Anhalt nur sehr wenige Siedlungen bekannt. Körperbestattungen hingegen, ob einzeln, in kleinen Gruppen oder begleitet von Tierdeponierungen, werden des Öfteren aufgedeckt. Gerade die bewusste Tötung von Rindern für einen Verstorbenen oder die paarweise Niederlegung von Rindern lassen nicht nur eine gewisse Prosperität erkennen, sondern belegen auch eine patriarchalisch aufgebaute Gesellschaft, in der einige wenige Männer Macht und Reichtum anhäuften. Dabei fallen höherwertige Beigaben auf: Schmuck, aufwendig verzierte Gefäße und vor allem Geräte – vorrangig aus Feuerstein gefertigte Beile. Egal in welcher Größe angefertigt, sind sie stets sorgfältig ausgeformt, geschliffen und meist glänzend poliert. Bei diesem Luxusgut dürfte, wie z. B. beim Bernsteinschmuck, ausgehend von einzelnen Spezialisten oder gar Handwerkerzentren ein überregionaler Handel eine weite Verbreitung ermöglicht haben. Waren die wertvollen Flintbeile der Kugelamphorenkultur vielleicht im Gegensatz zu jenen massenhaft beigegebenen, durchlochten Felsgesteinäxten der nachfolgenden Schnurkeramischen Kultur kein individueller Besitz?

Schlagwörter Kugelamphorenkultur, Flintbeile, Machtsymbole, Elitengräber, Landschaftsarchäologie

Aus der im östlichen Mitteleuropa von Polen bis ins niedersächsische Wendland verbreiteten, archäologisch gut belegten Kugelamphorenkultur kennen wir aus dem heutigen Sachsen-Anhalt nur wenige Siedlungen[1]. Gräber, die anhand der Keramik eindeutig der Kugelamphorenkultur zuzuordnen sind, liegen hingegen häufiger vor. Dominierend sind dabei aber meistens Vergesellschaftungen mit Funden und Befunden verschiedener einheimischer Kulturgruppen, die, wie die mitteldeutsche Bernburger Kultur, der späten Trichterbecherkultur oder, wie die böhmische Řivnáč-Kultur, dem Post-Badener Kulturkreis zuzurechnen sind. Deren charakteristische Gefäßtypen treten wiederum als »Begleitkeramik« zu den zweifelsfrei der Kugelamphorenkultur zuzuordnenden Repräsentativ-Keramiken auf[2].

Typisch für viele der einheimischen Kulturgruppen aus dem Zeithorizont der Kugelamphorenkultur – späte Trichterbecher- und Post-Badener-Zeit – sind feinkeramische Gefäße mit gestochenen und geritzten Dreiecks- und Winkelband-Mustern[3]. Sie sind von der Kostolac-Gruppe im Ostbalkan bis zur Eyersheimer Gruppe in Südwestdeutschland, zur Chamer Gruppe in Bayern und Böhmen sowie zur Havelländischen Kultur im nördlichen Mitteldeutschland verbreitet[4]. Typisch sind vor allem auch die schnurgerauten Unterteile, sowohl bei ansonsten unverzierten größeren Gebrauchsgefäßen als auch bei am Oberteil sorgfältig ver-

1 Saisonal während der Sommermonate genutzter Platz bei Eutzsch, Lkr. Wittenberg (Fahr 2018). Saisonal während der Wintermonate genutzter Platz bei Döbbelin, Lkr. Stendal (vgl. Katalogeintrag Döbbelin; vgl. Müller 2023; Szmyt 1999; Szmyt 2003).

2 Die sogenannten »Bernburger Tassen« der Řivnáč-Kultur, die Tassen vom Typ Meseberg der altmärkisch-lüneburgischen Gruppe der Kugelamphorenkultur oder die besonders in Sachsen häufigen Warzenkranzbecher.

3 Früher meistens dem Bernburger Stil zugerechnet.

4 Für den ostniedersächsischen, altmärkischen und havelländischen Raum hat J. Beran (in Vorb.) dafür die Bezeichnung Pevestorf-Parchim-Gruppe vorgeschlagen – nach dem Gräberfeld von Pevestorf (Meyer 1993) und der Siedlung von Parchim-Löddigsee (Becker/Benecke 2002).

zierten Amphoren. Für die Gruppen des ausgehenden Spätneolithikums um 3000 v. Chr. sind ausgesprochen wenige Gräber nachgewiesen. Vermutlich waren diese nur gering in den Boden eingetieft worden. Selten sind Brandbestattungen überliefert.

Ein ganz anderes Bild zeichnet sich für die Kugelamphorenkultur ab. Häufig wurden für die Niederlegungen aufwendige Stein- und Holzkonstruktionen errichtet. Zudem sind die Verstorbenen mit vielen erhaltungsfähigen Beigaben ausgestattet worden. Sogenannte Armenbestattungen sind nicht bekannt. Entweder wurden diese mangels Beigaben nicht als Begräbnisse der Kugelamphorenkultur erkannt oder sie waren geringer eingetieft und dadurch nicht bis heute erhalten oder es wurde ein völlig anderer Umgang mit diesen Verstorbenen praktiziert. Wir fassen daher im archäologischen Kontext ein relativ einheitliches Bild: Die einzeln oder in kleinen Gruppen angetroffenen Gräber enthalten höherwertige Beigaben an Schmuck, Waffen, Geräten sowie Speise- und Trinkgefäßen[5], gelegentlich zusammen mit Niederlegungen von Rindern und singulär wirkende Rinderdoppelbestattungen[6].

Über alle Regionalgruppen der Kugelamphorenkultur hinweg wurden den männlichen Verstorbenen mit großem Aufwand hergestellte Flintbeile mitgegeben. Diese mal kleiner, mal größer gefertigten Beile sind stets sorgfältig geformt bzw. geschliffen und glänzend poliert. Typologisch handelt es sich nach K. H. Brandt (1967, 118–122; Strahl 1985) um sogenannte dicknackige, dünnblattige Flint-Rechteckbeile[7]. Dieses Merkmal steht mit der Schäftungsweise in Zusammenhang[8]. Besonders kennzeichnend und auffallend ist die bei normaler bis auffallend großer Länge und Breite vergleichsweise geringe Dicke des Blattes. Die daher anzunehmende Bruchempfindlichkeit könnte gegen ein robustes Alltagswerkzeug sprechen, mit dem sich beispielweise Holz bearbeiten ließe. Eine Verwendung als Waffe wird in der Forschung immer wieder erwogen und erscheint vorstellbar (Beier 1988, 31). Nach U. Fischer (1956, 154) sollen die Flintbeile zumindest für das Saalegebiet die wirkungsvollste Waffe des Neolithikums gewesen sein[9].

Geradezu zweckdienlich erscheint hingegen die Herstellung der Beile der nachfolgenden endneolithischen Einzelgrabkultur. Es sind dicknackige, dickblattige, aus Feuerstein hergestellte Rechteckbeile (Jacobs 1991; Beran 1990; Strahl 1990). Sie sind neben den durchlochten aus Felsgestein gefertigten Streitäxten eine Art Zusatzbeigabe in den Bestattungen. Ihre Bedeutung dürfte weniger in der dekorativen Wirkung und dem damit verbundenen Ausdruck von Macht als in praxistauglichen Anforderungen für die Holzbearbeitung gelegen haben.

Gleiches dürfte für die Flint-Rechteckbeile vom breitschneidigen Typ (Forssander 1936, 132; Kühn 1979; Rassmann 1993) sowie dem Kregme-Typ (Forssander 1936, 133; Ebbesen 1975) gelten, die in das sogenannte nordische Spätneolithikum bzw. die Dolchzeit datiert werden können und welche wohl in der Tradition der Einzelgrabkultur eher nur grob ausgearbeitete Gebrauchswerkzeuge waren. Die Nachfolger der aus der Kugelamphorenkultur bekannten Flintbeile finden sich hinsichtlich Formgebung und besonders gründlichem Schliff am ehesten in den Flint-Rechteckbeilen der Schönfelder Kultur wieder (Wetzel 1979, 52). Eine zweifelsfreie Beurteilung fällt schwer, da diese zusammen mit dem Leichnam verbrannt wurden und somit ausschließlich als im Feuer zerborstene Bruchstücke vorliegen.

Die Flintbeile der Kugelamphorenkultur dürften weniger Werkzeuge, sondern vielmehr Statussymbole gewesen sein. Für den aus den Gräbern der Kugelamphorenkultur vergleichsweise häufig überlieferten Bernsteinschmuck wird über spezialisierte Herstellungszentren diskutiert und ein überregionaler Handel in Erwägung gezogen (Wiermann 2021, 196; Beran in Vorb.). Gleiches gilt sicher auch für die Flintbeile, wenngleich die aus dem südpolnischen, auffallend gebänderten Krzemionki-Feuerstein gefertigten Flintbeile den östlichen Gruppen der Kugelamphorenkultur vorbehalten waren (Beier 1988, 32; Wiermann 2021, 193; 194 Abb. 4). War die Westgruppe der Kugelamphorenkultur von diesem Austausch abgeschnitten?

Insgesamt gesehen, scheinen die mitteldeutschen Gebiete während der Kugelamphorenzeit fest in hierarchisch strukturierten Gesellschaften verankert. Besondere Persönlichkeiten wurden mit einem aufwendigen Grabbau und wertvollen Beigaben bestattet. Die Flintbeile betreffend kam es als Ausdruck großen Reichtums bzw. hoher gesellschaftlicher Stellung immer wieder zu einer Überausstattung – denn es ist kaum davon auszugehen, dass man in Dahlen, Lkr. Stendal (vgl. Katalogeintrag Dahlen), oder Jerchel, Lkr. Havelland (vgl. Katalogeintrag Jerchel), mit bis zu fünf Beilen einen Werkzeugmacher niederlegte, sondern vielmehr als Gemeinschaft einem höher gestellten Mitglied eine ganz besondere Ehre zukommen ließ. Auch wenn in Jerchel der Befundzusammenhang ungeklärt ist, fehlen Hinweise auf eine Mehrfachbestattung, welche eventuell die Vielzahl der Beile erklären würde. Anders verhält es sich in Döbbelin, Lkr. Stendal (vgl. Katalogeintrag Döbbelin). Dort liegt, situiert inmitten eines Siedlungsareales[10] zweifelsfrei eine Mehrfachbestattung vor. Das über 5 m² große Grab ist beräumt, möglicherweise von den eigenen Angehörigen. Die Anzahl der Bestatteten muss geschätzt werden. Im Vergleich mit dem Kollektivgrab von Koszyce, im Powiat Proszowicki in der Woiwodschaft Kleinpolen (Schroeder u. a. 2019), könnten gleichfalls zehn oder mehr Personen niedergelegt worden sein. Die DNA-Analysen der 15 niedergelegten Personen von Kozsyce belegen eine patrilineare Gesellschaft. Vier der

5 Ähnlich zu Adelsgräbern jüngerer Kulturen.
6 Aus der Eisenzeit sind – ggf. vergleichbar – Fürstengräber mit Prozessions- oder Streitwagen bekannt. Vgl. auch die kugelamphorenzeitlichen Wagengräber von Profen, Burgenlandkreis (Friederich/Hoffmann 2013; Friederich 2022).
7 In anderen Kulturen gibt es auch Flintbeilformen mit linsenförmigem Querschnitt, vor allem in der frühen Trichterbecher- und in der Einzelgrabkultur.
8 Es ist nicht auszuschließen, dass der Querschnitt mit der Herstellungsweise in Verbindung steht.
9 So war ein 10,2 cm langes Exemplar mit einem 50 cm langen Schaft aus Birkenholz versehen (Steinkistengrab von Niedereichstädt, Saalekreis); Beier 1988, 130; Taf. 84,2; vgl. Katalogeintrag Niedereichstädt.
10 Bzgl. Döbbelin scheint es sich um einen im Winter und damit saisonal genutzten Platz zu handeln. Vgl. auch die Hinweise zur Nutzung von Wald als Weide und geringe Eingriffe in die Landschaft für den Zeithorizont der Kugelamphorenkultur in der Altmark (Diers 2018, 196–200).

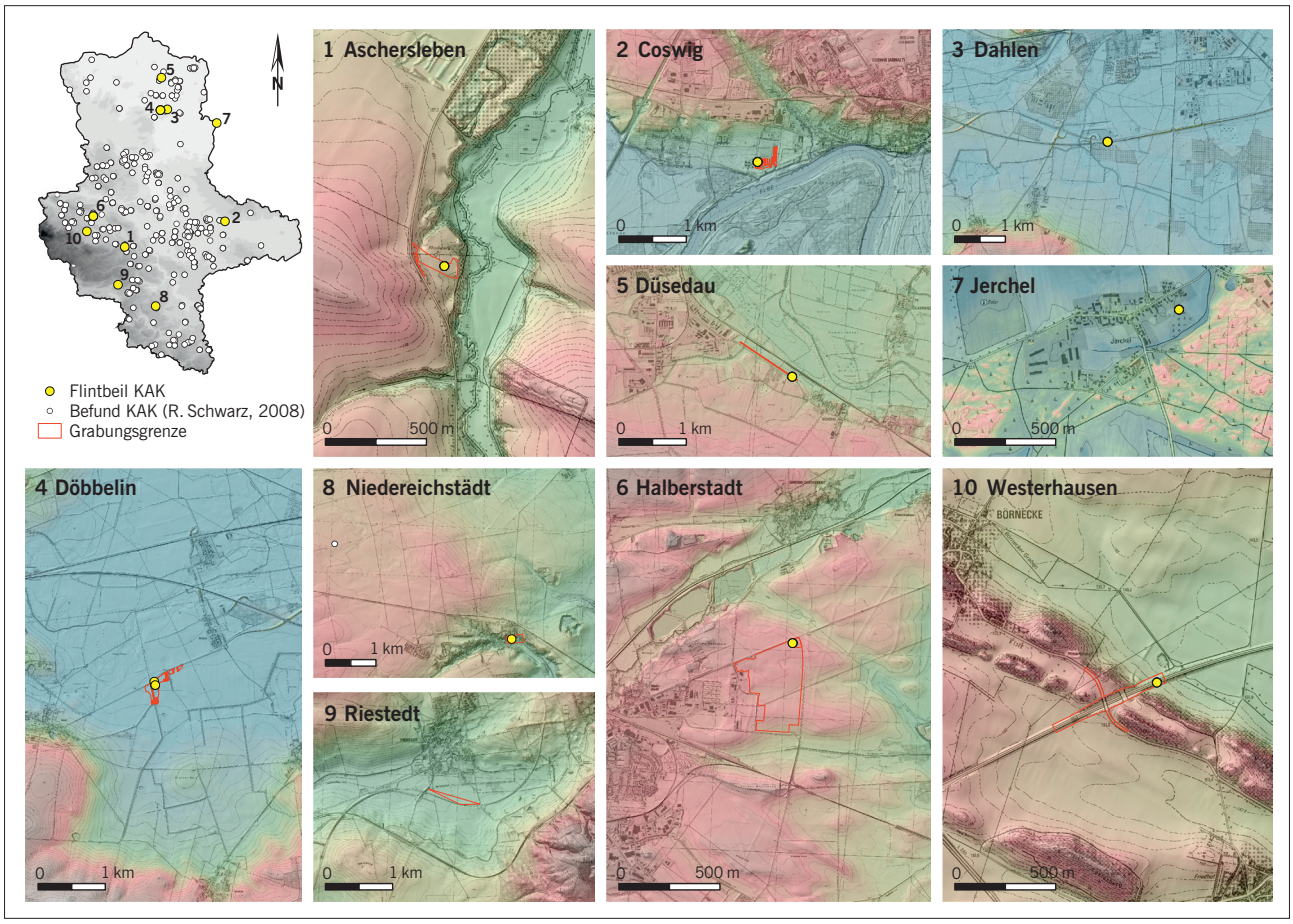


Abb. 1 Lage und Verteilung der Verteilung der im Text und Katalog besprochenen Fundstellen.

Fig. 1 *Location and distribution of the sites discussed in the text and catalogue.*

acht Männer sind Halbbrüder und weitere Verwandtschaftsverhältnisse zweiten Grades liegen bei den männlichen Individuen vor. Die Frauen hingegen sind nicht miteinander verwandt. Vergleichbare Befunde für derartige Untersuchungen sind aus Mitteldeutschland bislang nicht bekannt. Doch die deutliche Überbetonung von Reichtum bei männlichen Verstorbenen zeigt zumindest eine patriarchalische Gesellschaft an. In Westerhausen, Lkr. Harz (vgl. Katalogeintrag Westerhausen), Halberstadt, Lkr. Harz (vgl. Katalogeintrag Halberstadt), Niedereichstädt, Saalekreis (vgl. Katalogeintrag Niedereichstädt), Westdorf, Salzlandkreis (vgl. Katalogeintrag Westdorf), und gegebenenfalls auch in Riestedt, Lkr. Mansfeld Südharz (vgl. Katalogeintrag Riestedt), wurden verstorbene Männer in sorgfältig gesetzten Steinplattenkisten niedergelegt. Ein poliertes Flintbeil war ihnen stets mitgegeben worden. In einem Fall fassen wir ein sehr junges Individuum. Womöglich ließ man dem 6–7 Jahre alten Kind von Riestedt aufgrund seines offenkundigen Krankheitsbildes – ein Hydrozephalus[11] – oder vielleicht wegen einer Zugehörigkeit zur Herrschaftsdynastie das pompöse Begräbnis zukommen[12].

In der Harzregion wurden zahlreiche mit Flintbeilen ausgestattete Verstorbene an einer exponierten Stelle niedergelegt. Durch die Bestattung auf einem hochgelegenen Geländepunkt oder markanten Landschaftsmarker blieben die Grabstellen weithin sichtbar (Abb. 1). In Halberstadt wurde das kugelamphorenzeitliche Begräbnis sogar inmitten eines seit über 1000 Jahren immer wieder frequentierten heiligen Hains niedergebracht, von dem aus der Brocken gut sichtbar war (Fahr 2023; Fahr u. a. 2023). Ähnlich zum »Rinderbaron von Westerhausen« wurden Rinder in unmittelbarer Nähe zur menschlichen Bestattung niedergelegt. Möglicherweise war die symbolische Mitgabe der Rinderherden sogar im gesamten Harzumfeld üblich; in Westdorf überprägten zahlreiche jüngere Nutzungsphasen die neolithischen Horizonte und an anderen Plätzen waren die Untersuchungsfenster für die Erfassung weiträumiger Begräbnisareale mitunter nicht ausreichend groß. Allein die Flintbeile zeigen somit bis heute an, dass die Gesellschaft dem Verstorbenen einen großen Anteil des gemeinsamen Besitzes für das Jenseits mitgab.

Riestedt ist von seiner topografischen Lage zumindest für die Harzregion als Ausnahme zu betrachten. Die Grab-

11 Der sog. Wasserkopf wird als Folge einer Hirnhautentzündung (Meningitis) interpretiert (vgl. Katalogeintrag Riestedt).

12 Das jung verstorbene Individuum trug eine aus Hirschgrandeln gefertigte Kette um den Hals. Der erwachsene Tote von Westerhausen trug eine oder zwei aus durchlochten Kahnschnecken aufgefädelte Kette(n) um den Hals.

lege befindet sich inmitten eines Talkessels. Fassen wir hier wie bei Döbbelin und vermutlich auch bei Dahlen und Jerchel einen wiederkehrend saisonal genutzten Platz, der vor allem im Winter den Viehherden eine ausreichende Nahrungsgrundlage bot? Vergleichbar mit den weit in die Region ausstrahlenden Landschaftsmarken – wie beispielsweise Halberstadt, Westerhausen oder Westdorf – könnten Bereiche mit fruchtbaren Wiesen und Auenvegetation bedeutende herrschaftliche Bezugspunkte der offenbar patriarchalisch geprägten Gesellschaften widerspiegeln.

Die durch die Mitgabe von polierten Flintbeilen hervorstechenden Bestattungsplätze sind feste Bestandteile bzw. Kristallisationspunkte innerhalb der vom Menschen geschaffenen Kulturlandschaft. Das aufwändige, Reichtum inszenierende Bild einer Beisetzung von Halberstadt dürfte bewusst am Fuß einer wenige Jahrhunderte zuvor überhügelten Walternienburger Totenhütte stattgefunden haben[13]. Sicherlich war der Platz aufgrund seiner topografischen bzw. naturräumlichen Lage prädestiniert, doch dürfte gerade durch Eingliederung in die bereits etablierte Sepukrallandschaft dem hohen Rang der verstorbenen Person Rechnung getragen worden sein. Wie bedeutsam zur Zeit der Kugelamphorenkultur diese zusammen mit den Ahnen gelebte bzw. gestaltete Landschaft war, lässt sich stellvertretend an der Fundstelle Magdeburg-Eulenberg erläutern. Zwischen zwei beachtlichen Grabhügeln der Baalberger Kultur verlief – wie parallel zueinander niedergelegte Rindergespanne aufzeigen – ein Prozessionsweg (Dalidowski/Friederich 2024)[14]. Anders als bei den beiden von Rindern gezogenen Karren von Profen war der Wagenlenker nicht allein durch seine im Alltag gebräuchlichen Werkzeuge erkennbar (Friederich/Hoffmann 2013), sondern in einem Fall selbst in der Grube niedergelegt worden. Er führte keinerlei Beigaben; ebenso wenig wie solche im Umfeld der paarweisen Deponierung von Schweinen, kleinen Wiederkäuern (Schaf/Ziege) und Rindern vom Köthener, Lkr. Anhalt-Bitterfeld, Ensemble erkannt wurden (Dalidowski 2024; Friederich/Meller 2024). Sicherlich steht hinter derartigen Opferdarbietungen eine Gemeinschaft, die mitunter ihre wertvollsten Dinge – Garanten des Fortbestands der Viehherde bzw. Zugmaschinen (vgl. hierzu auch Burmeister 2011) – aus dem Wirtschaftsbereich entnahm (vgl. hierzu die Rinderdoppelbestattung aus Felchow, Lkr. Uckermark Dirks/Hanik 2024; Dirks 2020). Doch nur dann, wenn sich die Gesellschaft von ihrem »Häuptling« trennen musste, gab man zusätzlich ein oder mehrere Flintbeile mit[15]. Die sorgfältig geschliffenen, vielleicht eigens für die Beisetzung auf Hochglanz polierten Flintbeile der Kugelamphorenkultur sind Ausdruck einer sozialen Hierarchisierung: wenige männliche Mitglieder trugen – möglicherweise von Geburt an (vgl. Riestedt) – diese Insignie.

13 Datierungsansatz anhand von Keramiken und Radiokarbondatierung (unpubl., der als Großblock geborgene Befund wird derzeit freigelegt).

14 Ähnliche Prozessionswege der Trichterbecherkultur sind aus Jütland überliefert (Johannsen/Laursen 2010; siehe auch Burmeister 2019).

15 Inwieweit eine Überausstattung mit mehreren Beilen einen vergleichbaren Wert zu der Beigabe eines einzelnen Flintbeils bei aufwendiger Grabarchitektur oder der gleichzeitigen Niederlegungen von Herdentieren gehabt haben könnte, ist aufgrund der geringen Datenlage nicht abschließend zu beurteilen.

Katalog

In den vergangenen drei Jahrzehnten wurden bei den großen Baumaßnahmen jeweils vorgeschalteten Ausgrabungen einige mit Flintbeilen ausgestattete Gräber der Kugelamphorenkultur dokumentiert. Sie sind zwar in kurzen Berichten bereits publiziert, sollen aber komprimiert nochmals vorgestellt werden. Bereits im vorigen Jahrhundert dokumentierte Bestattungen mit Flintbeilen werden nur dann nochmals vorgestellt, wenn sie im Textteil erwähnt wurden.

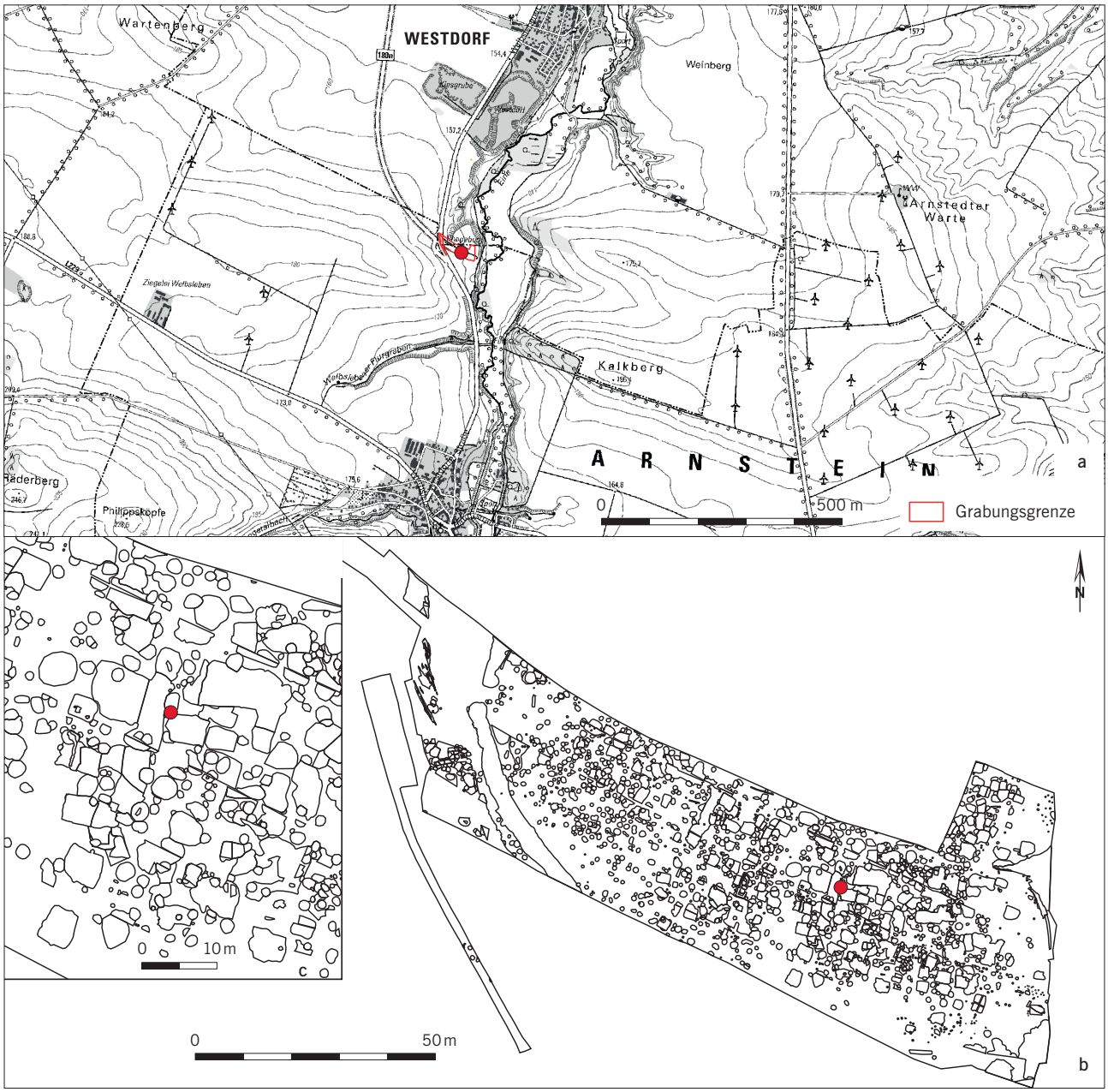


Abb. 2a–c Westdorf, Salzlandkreis. a Lage der Fundstelle. Der Platz wurde im Zuge eines Straßenbaus angeschnitten und dokumentiert. Die Position der kugelamphorenzeitlichen Bestattung ist mit einem roten Punkt markiert; b Grabungsplan mit der markierten kugelamphorenzeitlichen Bestattung; c vergrößerter Ausschnitt.

Fig. 2a–c *Westdorf, Salzlandkreis district. a Location of the site. It was discovered and documented during road construction. The position of the burial from the Globular Amphora Culture is marked with a red dot; b excavation plan with the marked burial from the Globular Amphora Culture; c enlarged detail.*

Westdorf, Salzlandkreis

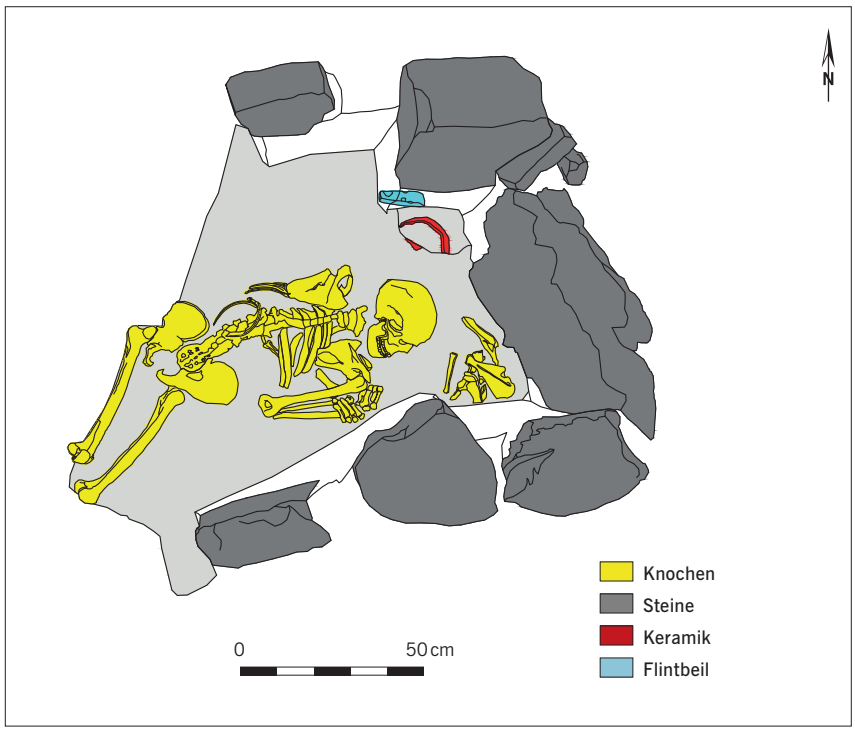
Ein Grab der Kugelamphorenkultur oberhalb der Eine

Christian Bogen, Stefan Dembinski, Susanne Friederich

Fundplatz	»Hohe Burg, Westdorf« (Fundstelle 9 der Gesamtmaßnahme)
Anlass	Straßenneubau Ortsumgehung Aschersleben/Süd–Quenstedt (B 180)
Zeitraum	März 2021 bis August 2022
Aktivitätsnummer	14663 (2. DA)
Grabungsleitung (Projektleitung)	C. Bogen, S. Dembinski (S. Friederich)
Topografische Lage	Auf einem Sporn oberhalb des tief in die Landschaft eingeschnittenen Einetals gelegen, welches mit seinen Steilhängen nach Osten, Norden und Westen einen natürlichen Schutz bietet. Im Süden geht das Gelände in eine flach nach Westen hin ansteigende Ebene über (Dembinski u. a. in Vorb.) (Abb. 2).
Befundart	Stark gestörtes Steinkistengrab (ca. 1,20 x 0,60 m)
Datierung	Kugelamphorenkultur
Literaturverweis	Dembinski u. a. (in Vorb.)

Abb. 3 Westdorf. Bef. 2684. Umzeichnung des Steinkistengrabes.

Fig. 3 *Westdorf. Feature 2684. Drawing of the cist.*



Das Steinkistengrab ist Nordost-Südwest ausgerichtet (Abb. 3). Der südwestliche Bereich des Grabes ist durch jüngere Befunde gestört. Im nordöstlichen Teil wurden Gerölle aus Sandstein und quaderförmige Steine aus Muschelkalk für das Steinkistengrab verwendet: Eine große Platte aus Muschelkalk bildet die nordöstliche Giebelwand, des Weiteren ist senkrecht eine kleinere Platte und ein großer quaderförmiger Sandstein erhalten. In der stark gestörten Kiste wurde ein männliches Individuum (adult–matur) in linker Hockerlage bestattet. Nordöstlich des Schädels befand sich ein Schulterblatt von Schaf/Ziege und ein Langknochen von einem Hund. Ein zerscherbtes Gefäß befand sich nordwestlich des Schädels. Das Beil wurde nördlich platziert (Abb. 4).

Die frühesten nachgewiesenen Siedlungsspuren auf dem Sporn gehören zur Salzmünder Kultur. Der Platz wurde später immer wieder aufgesucht, oft vornehmlich als Bestattungsareal. Diese frühen Zeugnisse der Platznutzung wurden durch eine jüngere, zeitweise sehr intensive Nutzung stark überprägt.

Abb. 4 Westdorf. Bef. 2684. Ein Flintbeil als Beigabe.

Fig. 4 *Westdorf. Feature 2684. A flint axe as a grave good.*

Funde:

Steinkiste: Bef. 2684

- Keramikscherben
- 1 Flintbeil: HK-Nr. 14663:2684:4 (rechteckiger Querschnitt, leicht gewölbte Schneide geschliffen, Länge 12 cm)
- 1 Feuerstein: HK-Nr. 14663:2684:17a
- Tierknochen: HK-Nr. 14663:2684:3a,10a,11a,12a

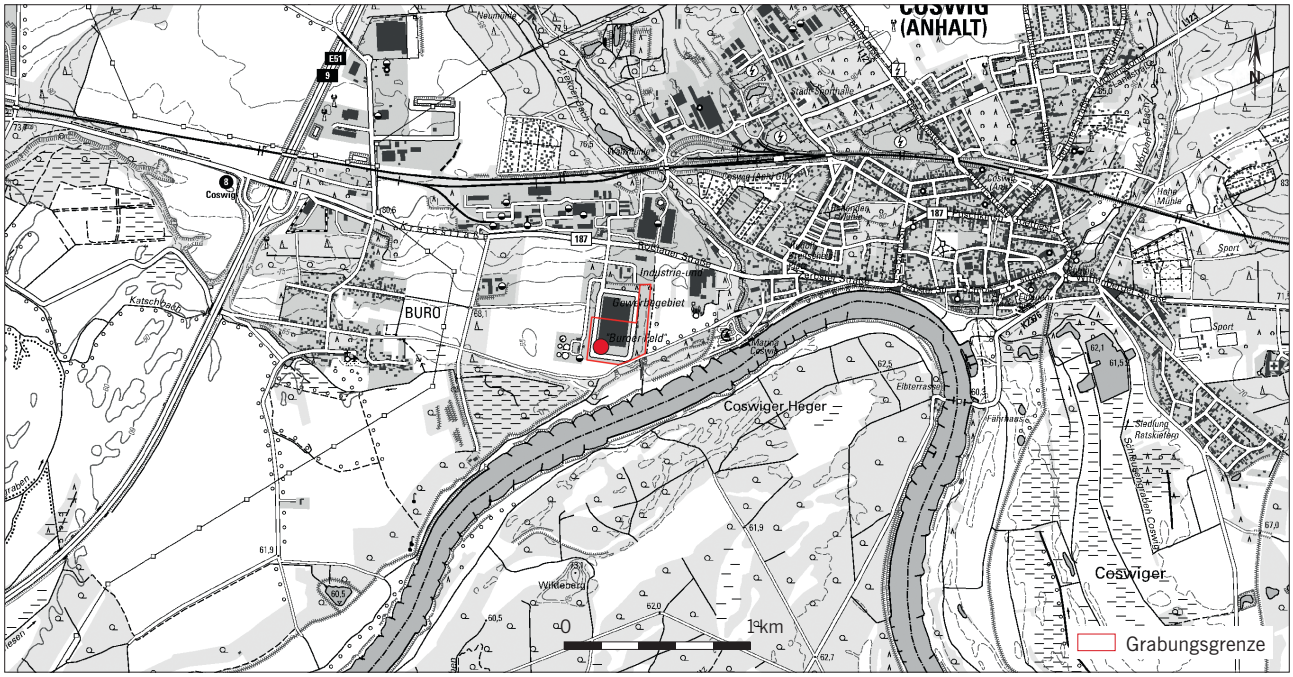


Abb. 5 Lage der Fundstelle Buroer Feld, Coswig, Lkr. Wittenberg. Der Platz wurde im Zuge einer Gewerbeansiedlung dokumentiert. Die Position der kugelamphorenzeitlichen Bestattungen ist mit einem roten Punkt markiert.

Fig. 5 *Location of the site Buroer Feld, Coswig, Wittenberg district. The site was documented when a subdivision for business was being developed. The position of the burials from the Globular Amphora Culture are marked with a red dot.*

Coswig, Buroer Feld, Lkr. Wittenberg

Zwei Bestattungen der Kugelamphorenkultur

Murat Dumlupinarli

Fundplatz	Buroer Feld, Coswig
Anlass	Erweiterung Gewerbegebiet
Zeitraum	Oktober 2001 bis Dezember 2001
Aktivitätsnummer	400 (2. DA)
Grabungsleitung (Projektleitung)	T. Schunke, M. Sopp (A. Hille)
Topografische Lage	Hochuferhöhe über Elbniederung; schwach geneigter Südhang (Abb. 5)
Befundart	zwei sich überlagernde Erdgräber
Datierung	Kugelamphorenkultur
Literaturverweis	Hille/Sopp 2001

Während der Zeit der Kugelamphorenkultur wurden auf der Hochuferfläche zwei Gräber angelegt; sie überschneiden sich. Inwieweit eine Gleichzeitigkeit vorliegt, lässt sich nicht erkennen. Es liegen zudem keine absolutchronologischen Daten vor (Hille/Sopp 2001). Die Knochen waren aufgrund des sauren Sandbodens des Flämings vollständig vergangen (Hille/Sopp 2001).

Grab 1 (Bef. 52B; Abb. 6) ist Ost-West ausgerichtet. Anhand der Grabbeigaben lässt sich trotz fehlender Knochenerhaltung eine Niederlegung in Hockerlage rekonstruieren (Hille/Sopp 2001). Ein Kumpf wurde am Hinterkopf des Toten platziert. Über den Knien stand ein weitmündiger Topf. Zwei Flintbeile lagen hinter seinem Rücken (Abb. 7). Der Befund überlagert randlich Grab 2 (Bef. 50B), das mit gleicher Ausrichtung ein wenig östlicher lag. Für das Individuum wird ebenfalls eine Hockerlage angenommen, in dessen Kopfbereich sich ein weitmündiger Topf befand. Aus dem Überschneidungsbereich der Grabgruben liegt ein zu Grab 2 gehörendes Flintbeil vor (Abb. 8).

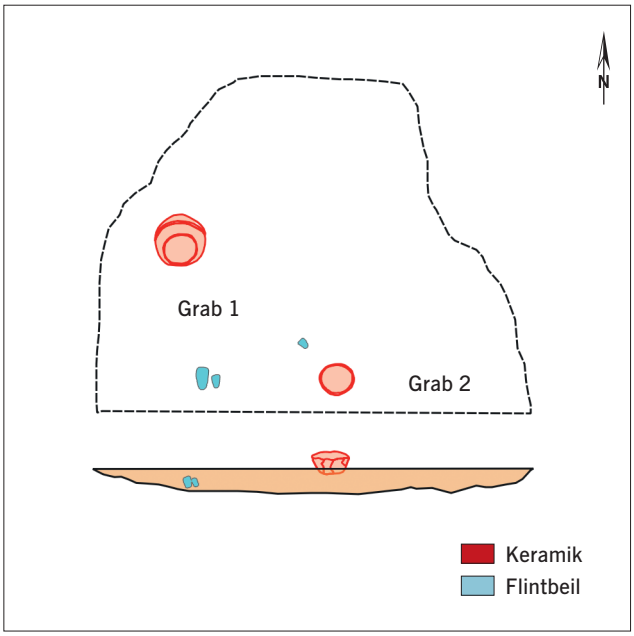


Abb. 6 Coswig, Buroer Feld. Umzeichnung von Grab 1 und 2; o. M.

Fig. 6 *Coswig, Buroer Feld. Drawing of Grave 1 and 2; no scale.*

Weitere Befunde der Kugelamphorenkultur wurden auf dem 16 ha großen Areal nicht erkannt. Während der späten Bronzezeit bzw. frühen vorrömischen Eisenzeit wurde das Gelände erneut als Bestattungsareal genutzt.

Abb. 7 Coswig, Buroer Feld. Grab 52. Ein Flintbeil als Beigabe.

Fig. 7 *Coswig, Buroer Feld. Grave 52. A flint axe as a grave good.*

Abb. 8 Coswig, Buroer Feld. Grab 50. Auch hier fand sich ein Flintbeil als Grabbeigabe.

Fig. 8 *Coswig, Buroer Feld. Grave 50. Here, too, a flint axe was used as a grave good.*

Funde:

Grab 1 Bef. 52B
- 2 Töpfe, 1 Kumpf: HK-Nr. 14688:66:3, 14688:66:6, 14688:66:18
- 2 Flintbeile: HK-Nr. 400:50:1378 (rechteckiger Querschnitt geschliffen, Länge 8 cm)

Grab 2 Bef. 50B
- 1 weitmündiger Topf
- 1 Flintbeil: HK-Nr. 400:52:1373 (trapezförmig, leicht gewölbte Schneide, Länge 7 cm)

Dahlen, Stadt Stendal, Lkr. Stendal

Jonas Beran

Fundplatz	Fpl. 2, Ackerfläche, Flurbezeichnung »Großer Heidberg«, wohl nach ehemals vorhandenem bronzezeitlichem Grabhügel
Anlass	Neubau der ICE-Strecke Hannover–Berlin, Südumfahrung von Stendal
Zeitraum	September 1991 bis April 1993
Aktivitätsnummer	30 (2. DA)
Grabungsleitung (Projektleitung)	J. Beran (A. Kurzhals)
Topografische Lage	Tangermünder Hochfläche, ebene Grundmoräne
Befundart	Körperbestattung ohne Steinverwendung
Datierung	Kugelamphorenkultur
Literaturverweis	Wetzel 1979; Meyer 1993; Beran/Beier 1994; Beran u. a. 2016; Beran in Vorb.

Die einem bronzezeitlichen Urnengräberfeld geltende Rettungsgrabung auf der Trasse der ICE-Strecke Hannover–Berlin erbrachte zwei Körpergräber der klassischen Kugelamphorenkultur; sie sind selbst für diese Kultur überdurchschnittlich reich ausgestattet (Beran/Beier 1994; Beran in Vorb.). Eine dritte, eventuell größere, zerstörte Grabanlage deutet sich durch Keramikfunde, ein Streitaxtfragment, Rinderzahnreste und Steinkonzentrationen an.

Keramikscherben des Pevestorf-Parchim-Stils – stichverziert oder schnurgeraut – streuen über eine große Fläche. Hinzu kommen Fragmente ausgeglühter Flintbeile und Klingen sowie zahlreiche querschneidige Pfeilspitzen. Es dürfte sich daher um Reste zerpflügter, flach angelegter Brandgräber der Kugelamphorenkultur handeln[16]. Weiterhin könnten es auch Hinterlassenschaften sekundärer Kulthandlungen auf dem Gräberfeld sein, wie sie für Pevestorf und die jüngeren Brandgräberfelder der Schönfelder Kultur angenommen werden (Wetzel 1979, 92–93; Meyer 1993, 17–27).

16 Eine vergleichbare Situation ist aus Potsdam bekannt, dokumentiert im Jahr 2012 (Beran u. a. 2016).

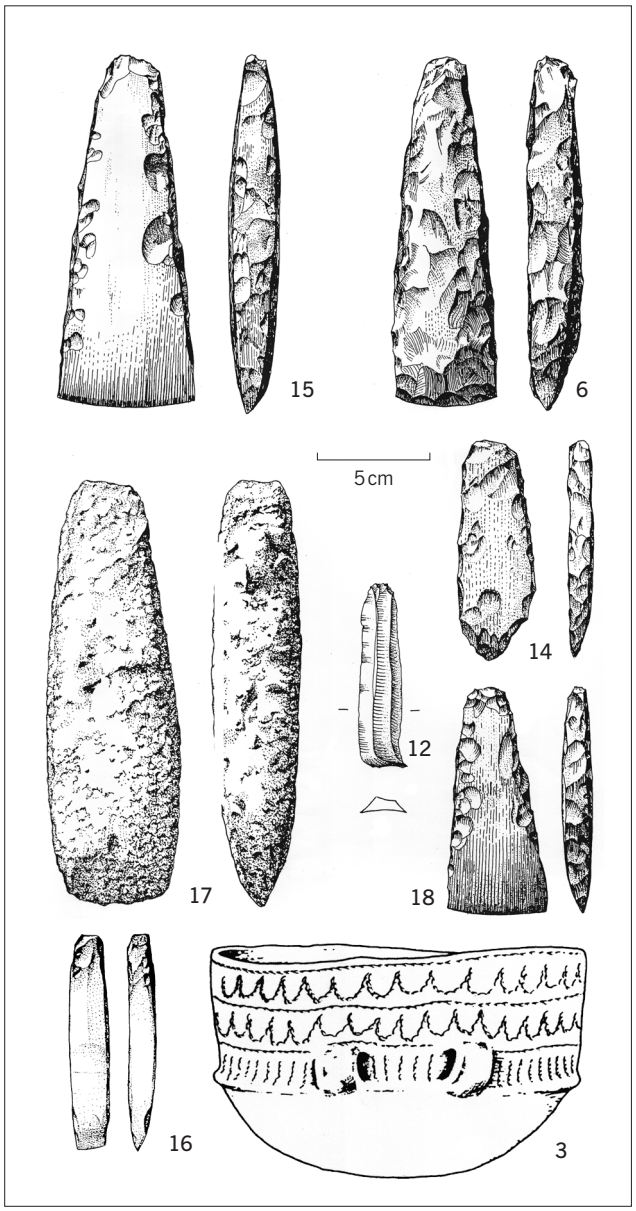


Abb. 9 Dahlen, Lkr. Stendal. Auswahl der Beigaben zur Körperbestattung Komplex 116. Geräte aus Feuerstein und Felsgestein sowie eine schnurverzierte Schale. Nummerierung nach Aufzählung der Objektnummern.

Fig. 9 *Dahlen, Stendal district. Selection of grave complex 116. Flint and rock tools and a cord-decorated bowl. Numbering by enumeration of the object numbers.*

Befundkomplex 108

Die Bestattung vermutlich einer Frau – Knochen waren im Sandboden vollständig vergangen – enthielt neben drei Gefäßen einen aus neun Teilen bestehenden, im Umfang und vor allem in den Abmessungen des größten Stückes den nach unserer bisherigen Kenntnis umfangreichsten neolithischen Bernsteinschmuck Mitteleuropas.

Befundkomplex 116

Die 8 m davon entfernt liegende vermutliche Männerbestattung enthielt vier Gefäße, einen Bernsteinanhänger und ebenfalls rekordverdächtige fünf steinerne Großgeräte bzw. Steinbeile (Abb. 9) im weiteren Sinne. Sie war von einer Grube überlagert, die Keramik vom Pevestorf-Parchim-Stil enthielt. Das große und das kleinere Flintbeil sind besonders flach, sorgfältig geschliffen und poliert und offenbar noch unbenutzt. Zusammen mit dem kleinen, gut geschliffenen Meißel bilden sie die gehobene Standardausstattung. Besonderheiten sind das große, sorgfältig zugeschlagene, aber noch gänzlich ungeschliffene Beil und ein weiteres in seiner Größe dem kleineren gut erhaltenen Exemplar entsprechendes Beil mit zerstörtem Schneidenbereich, das offenbar als Feuerschläger benutzt worden ist. Derartige primär als solche hergestellte Feuerschläger mit meist dreikantigem Querschnitt sind eine Standardbeigabe in Körpergräbern der Havelländischen Kultur und in mecklenburgischen Megalithgräbern.

Für das große Grünsteinbeil konnte nicht entschieden werden, ob es sich um ein noch nicht geschliffenes unfertiges Stück handelt oder ob die raue Oberfläche durch Verwitterung entstanden ist.

Die Belegung des postulierten zerstörten Brandgräberfeldes endet noch vor Beginn der klassischen Schönfelder Nordgruppe. Es folgt eine Siedlung der späten Einzelgrabkultur (Zonenbecher, Riesenbecher) und der Aunjetitzer Kultur, bevor hier wiederum das bronzezeitliche Brandgräberfeld angelegt wird.

Die eher einer frühen Phase der Kugelamphorenkultur zugehörenden Körpergräber ohne einheimische Begleitkeramik könnten etwas älter als die Brandgräber sein und am Beginn der Belegung des Platzes stehen. Sie könnten aber auch mit dem Beginn der Belegung des Brandgräberfeldes zeitgleich sein.

Funde:

Vergangene Körperbestattung: Kompl. 116 (HK 93:318)

- Objekt 15: 1 dünnblattig, dicknackiges Flintbeil mit rechteckigem Querschnitt, Nacken spitz zulaufend, allseitig partiell geschliffen, Schneide poliert, keine Gebrauchsspuren, keine Schäftungspolitur, hellgrau gefleckt, Länge 15,5 cm, Schneidenbreite 6,2 cm, Dicke 2,3 cm
- Objekt 18: 1 dicknackiges, dünnblattiges, dechselartiges Flintbeil mit rechteckigem Querschnitt, Nacken schmal zulaufend, allseitig partiell geschliffen, Schneide poliert, keine Gebrauchsspuren, keine Schäftungspolitur, hellgrau–braun gefleckt, Länge 9,9 cm, Schneidenbreite 4,4 cm, Dicke 1,3 cm
- Objekt 6: 1 dicknackig, dünnblattiges Flintbeil, Nacken spitz zulaufend, Oberfläche nicht geschliffen, hell bräunlichgrau, Länge 15,4 cm, Schneidenbreite 4,5 cm, Dicke 2,4 cm
- Objekt 14: dicknackiges, dünnblattiges, dechselartiges Flintbeil, eine Breitseite überschliffen, Schneide ausgebrochen, umgearbeitet zu Kratzer oder Feuerschläger, dunkelgrau mit hellen Streifen, Länge 9,6 cm, Schneidenbreite ca. 4 cm, Dicke 1,1 cm
- Objekt 16: dicknackiger, dechselartiger Flintmeißel, allseitig geschliffen, Schneide mit ganz schwachen Gebrauchsspuren, Nackenhälfte mit deutlicher Schäf-

tungspolitur, hellgrau gefleckt, Länge 9,8 cm, Schneidenbreite 1,4 cm, Dicke 1,3 cm
- Objekt 17: dicknackig, dickblattiges Beil mit rechteckigem Querschnitt und schmaler zulaufendem Nacken aus graugrünem Diabas, Oberfläche rau, kaum geschliffen oder schon stark verwittert, eine Breitseite wohl schwach überschliffen, Länge 18,5 cm, Schneidenbreite 5 cm, Dicke 3,9 cm
- Objekt 12: lange Klinge aus bräunlichgrauem, weiß gepunktetem Feuerstein, eventuell Importflint, mit undeutlicher Gebrauchsretusche, Länge 8 cm
- Objekt 3: Schale mit nebenständigem Henkelösenpaar in Höhe des Umbruchs, auf Umbruch plastische Leiste, am Hals zwischen umlaufenden Schnurlinien zwei Girlanden aus Schnureindrücken und oberhalb des Umbruchs kurze senkrechte Schnurfransen, graubraun gefleckt, Höhe 10,2 cm, größter Dm 16,5 cm, Wandstärke 0,5 cm

Weitere Beigaben bzw. Funde aus der Grabgrube
- 2 Kugelamphoren, 1 konischer Topf, 1 Bernsteinscheibe mit zentraler Bohrung, 1 dreikantig abgerundeter Quarzitkiesel, an beiden Enden beschädigt, vielleicht durch Feuerschlagen, 5 Flintabschläge

Abb. 10 Lage der Fundstelle Döbbelin, Lkr. Stendal. Der Platz wurde im Zuge des Autobahnbaus der A 14 dokumentiert. Die Positionen der kugelamphorenzeitlichen Bestattungen sind jeweils mit einem roten Punkt markiert.

Fig. 10 *Location of the site of Döbbelin, Stendal district. The site was documented during the construction of motorway A 14. The positions of the burials from the Globular Amphora Culture are each marked with a red dot.*

Döbbelin, Lkr. Stendal

Kugelamphorenzeitliche Winterstation mit drei beräumten Grablegen

Susanne Friederich, Uwe Kraus, Mariola Raczkowska-Jones

Fundplatz	Döbbelin (Fst. 11)
Anlass	Autobahnbau BAB 14 VKE 1.5 Süd
Zeitraum	April 2021 bis Dezember 2021
Aktivitätsnummer	14688 (2. DA)
Grabungsleitung (Projektleitung)	M. Raczkowska-Jones (Susanne Friederich)
Osteologische Bestimmung	C. Oelschlägel
Anthropologische Bestimmung	J. Orschiedt
Topografische Lage	Die Fundstelle liegt südlich einer Auenlandschaft am Buchholzgraben. Das Gebiet war Teil des alten Uchte-Gewässernetzes und wurde während der Elstereiszeit geformt (Abb. 10).
Befundart	3 Grabstellen: eine beräumte Mehrfachbestattung, zwei weitere mögliche Mehrfachbestattungen, ebenfalls beräumt (Abb. 11)
Datierung	Typologisch datiert die Fundstelle um 2900 v. Chr. (Altmärkisch-Lüneburger Gruppe).
Literaturverweis	Wetzel 1979; Beier 1988; Meyer 1993; Beran/Beier 1994; Woidich 2014; Schroeder u. a. 2019; Schwarz 2021; Beran in Vorb.

Grab 1 (Bef. 66) ist Nordwest-Südost ausgerichtet. Der Befund ist 0,4 m tief erhalten. Die im oberen erhaltenen Bereich 2,90 x 1,84 m große Grabgrube verjüngt sich bis zur Sohle auf 2,50 x 1,20 m (Abb. 12). Es wurden 14 Gefäße niedergelegt: fünf an der Nordwestseite, darunter eine Kugelamphore und ein weitmündiger Topf (Abb. 13,1.5), neun an der Südostseite, darunter zwei Kugelamphoren, eine Tasse und ein Topf (Abb. 13,3). Zwischen der Kugelamphore und den Topf fanden sich auch ein dislozierter menschlicher Schädel eines 30–40 Jahre alten Individuums und ein Unterarmknochen. Darüber hinaus lagen unmittelbar dabei Tierknochen (Rind und Hund); verstreut lagen kleine durchlochte Hundezähne (Abb. 14). Aus dem nordwestlichen Befundareal liegt ein Flintbeil vor, aus der größeren Fundmassierung drei weitere (Abb. 15). Das Grab wirkt beräumt, wenngleich eindeutige Spuren einer nochmaligen Öffnung des Befundes fehlen. Aus einem vergleichbar großen Massengrab der Kugelamphorenkultur in Koszyce, Südpolen, sind 15 Individuen bekannt (Schroeder u. a. 2019).

Die aus Bef. 66 geborgenen Gefäße zeigen eine späte Phase innerhalb der Kugelamphorenkultur an (vgl. Schwarz

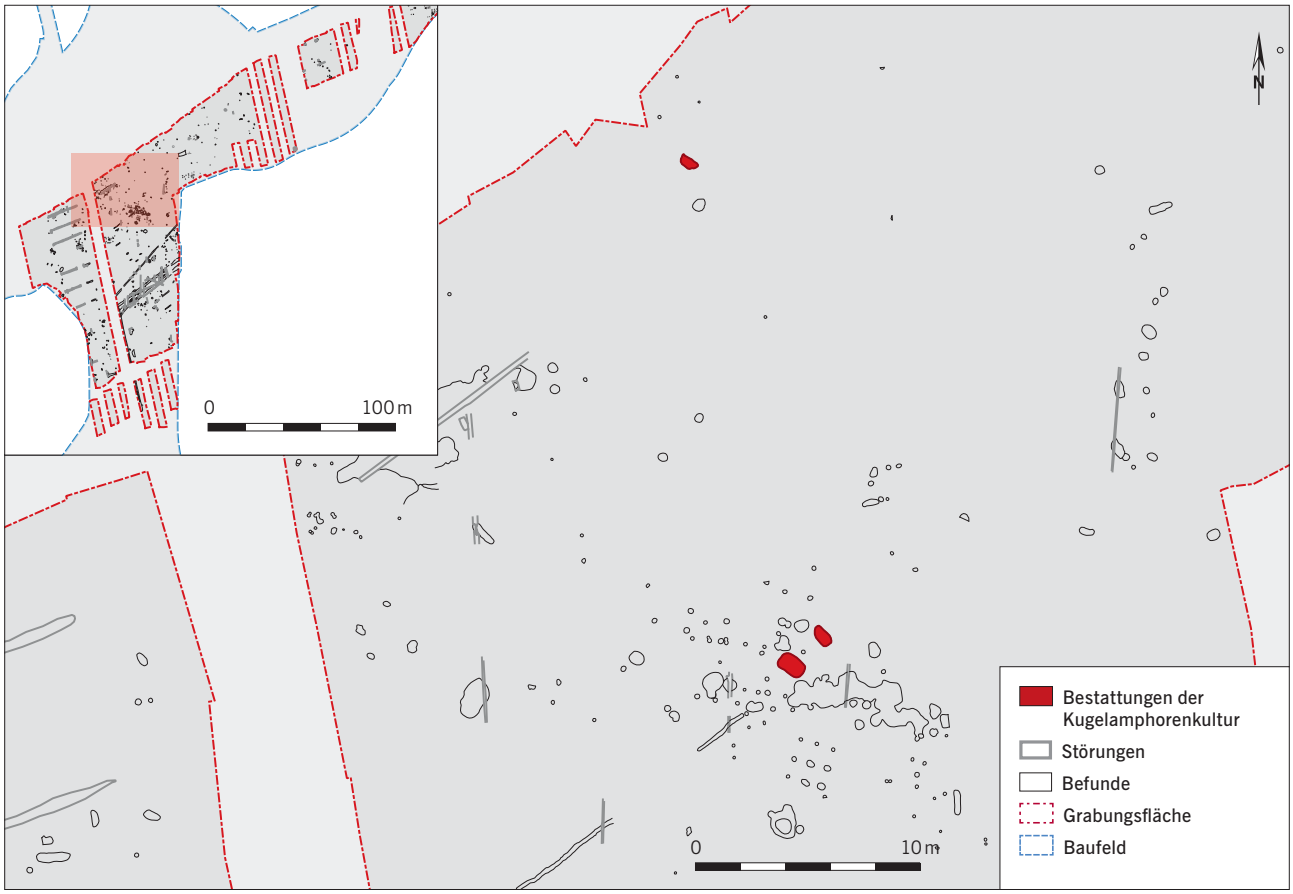


Abb. 11 Döbbelin. Grabungsplan mit eingezeichneten kugelamphorenzeitlichen Bestattungen.

Fig. 11 *Döbbelin. Excavation plan with marked burials from the Globular Amphora Culture.*

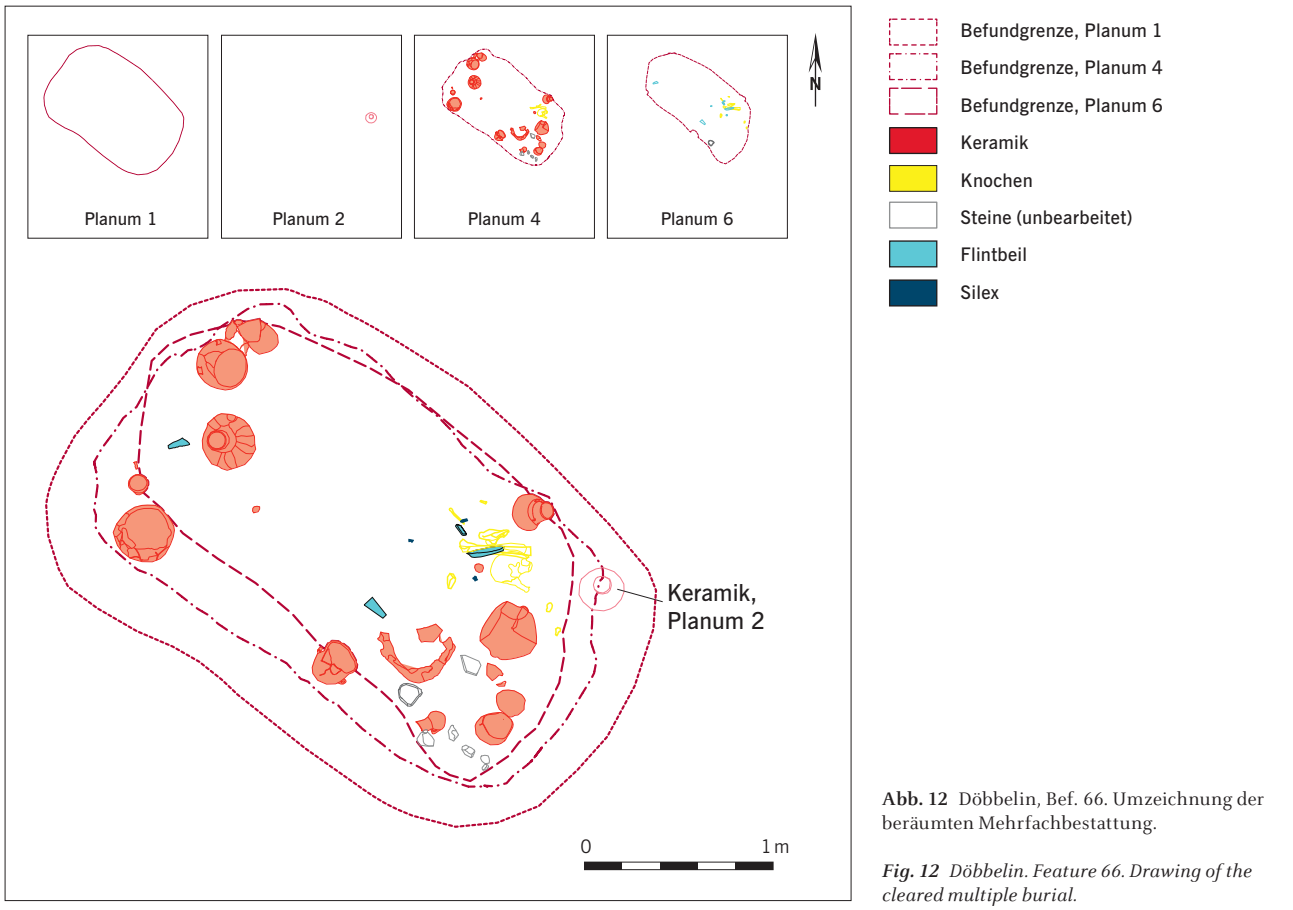


Abb. 12 Döbbelin, Bef. 66. Umzeichnung der beräumten Mehrfachbestattung.

Fig. 12 *Döbbelin. Feature 66. Drawing of the cleared multiple burial.*

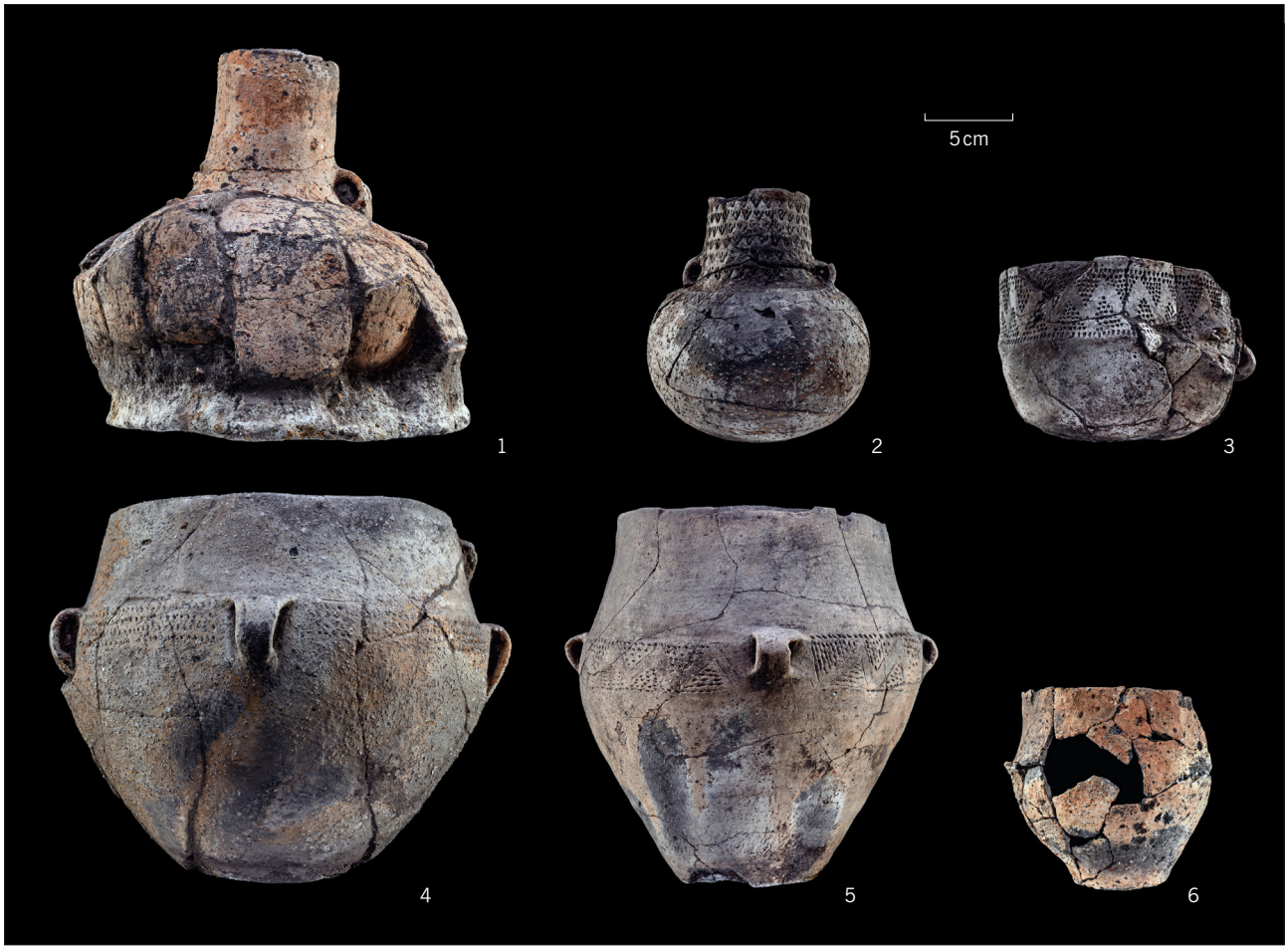


Abb. 13 Döbbelin, Bef. 66. Keramik. 1–2 Kugelamphore; 3 Tasse; 4–6 weitmündige Töpfe.

Fig. 13 *Döbbelin, Feature 66. Pottery. 1–2 Globular amphorae; 3 cup; 4–6 wide-mouthed pots.*

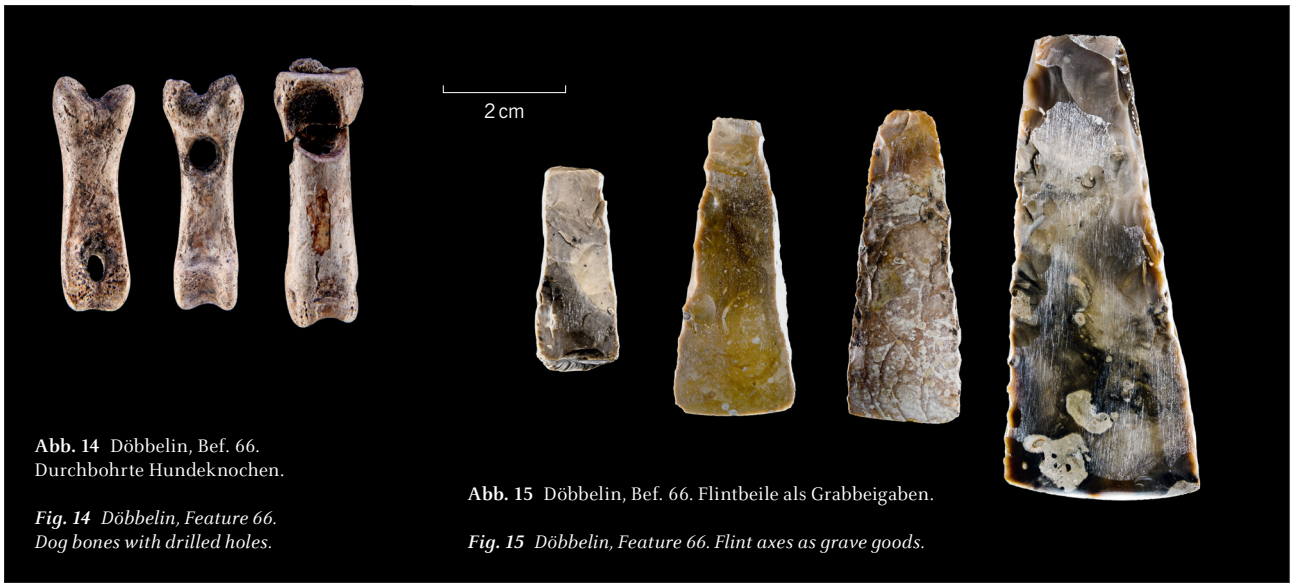


Abb. 14 Döbbelin, Bef. 66. Durchbohrte Hundeknochen.

Fig. 14 *Döbbelin, Feature 66. Dog bones with drilled holes.*

Abb. 15 Döbbelin, Bef. 66. Flintbeile als Grabbeigaben.

Fig. 15 *Döbbelin, Feature 66. Flint axes as grave goods.*

2021, 80–81), zumal es sich um ein Mischinventar mit Elementen der späten Bernburger Kultur handelt. Zumindest die Gräber umfassen eine »Kugelamphoren-Bernburg-Hybridkeramik«[17]. Auch das Material der umliegenden Befunde deutet auf eine Sphäre spätmittelneolithischer Kulturerscheinungen hin, wie sie z. B. in Pevestorf, Lkr.

17 Vgl. hierzu Woidich 2014, 204; ebenso die »altmärkisch-lüneburgische Lokalgruppe der KAK« bei Meyer 1993, 49–50 und Beier 1988, 73–74.

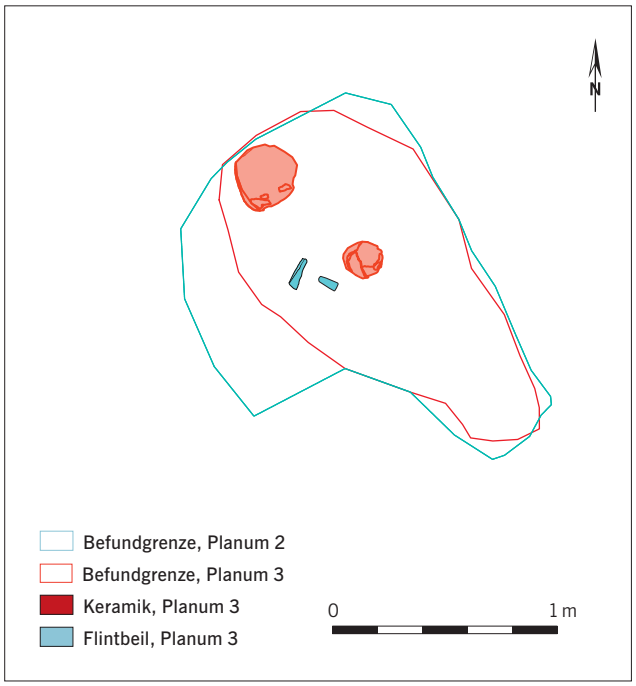


Abb. 16 Döbbelin, Bef. 76. Umzeichnung der Bestattung.

Fig. 16 *Döbbelin, Feature 76. Drawing of the burial.*

Lüchow-Dannenberg (Meyer 1993), und insbesondere im nur ca. 5 km entfernten Dahlen (Beran/Beier 1994; Beran in Vorb.) erfasst wurde. Vom Fundplatz Döbbelin liegt zudem eine von G. Wetzel (1979, 50) definierte »Arneburger Amphore« vor, wie sie für die »Fischbecker Gruppe« der frühen Schönfelder Kultur charakteristisch ist (vgl. Wetzel 1979, 222; Taf. 1,7). Zwar erschwert die meist verwitterte Oberfläche der Siedlungsware die Ansprache der mehrheitlich ockergelb–orangen Scherben. Diese Oberfläche ist laut J. Beran und H.-J. Beier (1994, 59) ebenso typisch für die Fischbecker Gruppe der Schönfelder Kultur.

Mit gleicher Nordwest-Südost-Ausrichtung liegt 3 m nordöstlich Grab 2 (Bef. 76). Der 0,3 m tief erhaltene Befund wirkt im oberen Bereich mit einer Größe von 2,30 x 1,38 m vergleichbar zu Grab 1 (Bef. 66), verjüngt sich jedoch an der Sohle auf 1,7 x 0,8 m (Abb. 16). Aus der nordwestlichen Befundhälfte ist ein Topf und eine Kugelamphore überliefert (Abb. 17). Westlich der Kugelamphore wurden zwei Flintbeile platziert (Abb. 18). Trotz guter Erhaltungsbedingungen fehlen Knochen, ebenso Hinweise auf einen Beraubungstrichter.

Grab 3 (Bef. 263) liegt 52 m nördlich der beiden Gräber 1 und 2. Es ist gleichfalls Nordwest-Südost ausgerichtet. Der ca. 1,90 x 0,95 m große Befund ist nur noch wenige Zentimeter tief erhalten. Im nordwestlichen Bereich befanden sich zwei Gefäße, jedoch keine Beile (Abb. 19). Knochen sind nicht überliefert. Hinweise auf eine nochmalige Befundöffnung wurden nicht erkannt.

Die drei Gräber liegen inmitten eines Siedlungsareals der Kugelamphorenkultur. Dieses ist innerhalb der 70 m breiten Autobahntrasse aktuell auf 230 m Länge erfasst. Im Jahr 2024 wird der nördliche Anschlussbereich im Nahbereich einer noch genutzten Umfahrungsstraße und einer vormaligen Dammschüttung untersucht. Von dort ist mindestens ein Brunnen bekannt. Weitere Wasserentnahmestellen und Gebäudestrukturen liegen vom Fundplatz vor.

Funde:

Mehrfachbestattung Bef. 66

- 3 Kugelamphoren: HK-Nr. 14688:66:8, 14688:66:10, 14688:66:17

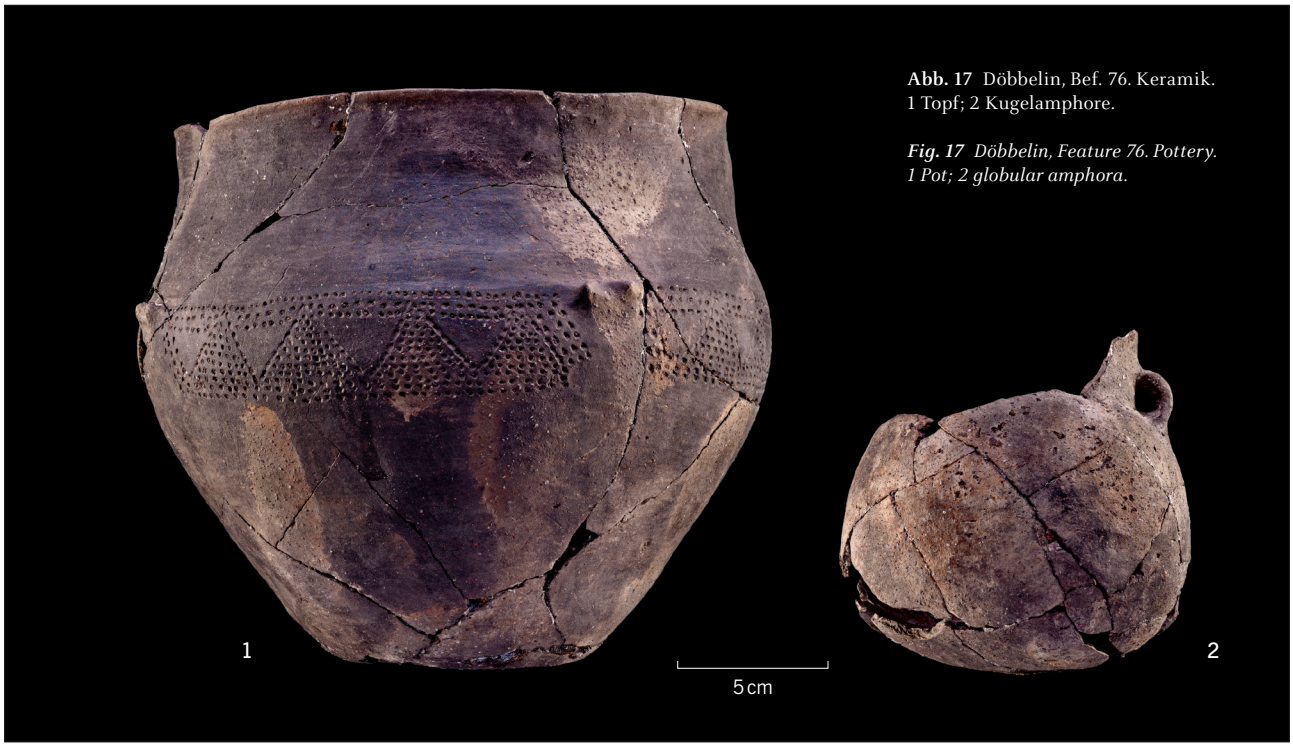


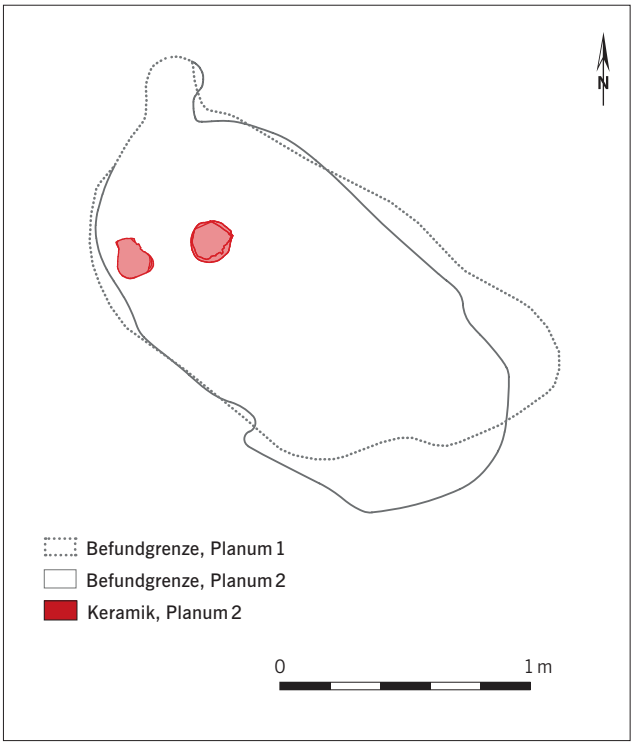
Abb. 17 Döbbelin, Bef. 76. Keramik. 1 Topf; 2 Kugelamphore.

Fig. 17 *Döbbelin, Feature 76. Pottery. 1 Pot; 2 globular amphora.*

Abb. 18 Döbbelin, Bef. 76. Flintbeile als Grabbeigaben.

Fig. 18 *Döbbelin, Feature 76. Flint axes as grave goods.*

- 2 Töpfe mit je 4 Henkeln auf der Schulter: HK-Nr. 14688:66:9, 14688:66:11
- Tasse: HK-Nr. 14688:66:7
- Gefäße: HK-Nr. 14688:66:1, 14688:66:2, 14688:66:3, 14688:66:4, 14688:66:6, 14688:66:12, 14688:66:18
- 4 Flintbeile: HK-Nr. 14688:66:13 (trapezförmig, geschliffen, 18,2 cm), HK-Nr. 14688:66:14 (trapezförmig, geschliffen, Länge 10,8 cm), HK-Nr. 14688:66:15 (trapezförmig, geschliffen, Länge 11,3 cm), HK-Nr. 14688:66:16 (rechteckiger Querschnitt, teilweise geschliffen, Länge 7,4 cm)
- 1 Silexklinge: HK-Nr. 14688:66:226a
- 1 Silexabschlag: HK-Nr. 14688:66:221
- 22 Silexartefakte: HK-Nr. 14688:66:222–225, 14688:66:226b, 14688:66:227
- 2 Knochenpfrieme: HK-Nr. 14688:66:195, 14688:66:196
- Tierknochen: HK-Nr. 14688:66:205a (Rind von 3 Jahren), HK-Nr. 14688:66:205b (2 Phalangen vom Hund), HK-Nr. 14688:66:243a (2 dorsal plantar durchbohrte Phalangen vom Hund), HK-Nr. 14688:66:242 (2 dorsal plantar durchbohrt Phalangen vom Hund)
- Menschenknochen: HK-Nr. 14688:66:197–199, 14688:66:201–204,207–208, 14688:66:229, 14688:66:231



Einzelbestattung Bef. 76

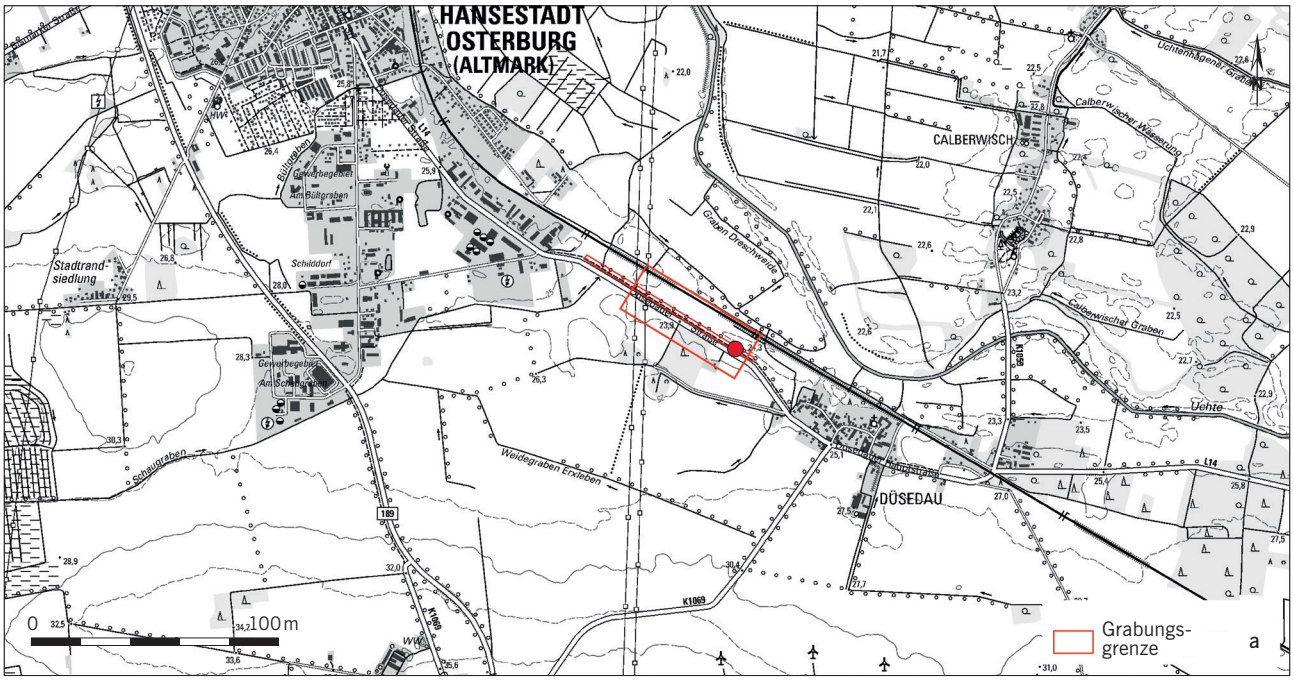
- 1 Topf: HK-Nr. 14688:76:79
- 1 Kugelamphore: HK-Nr. 14688:76:80
- 2 Flintbeile: HK-Nr. 14688:76:71 (rechteckiger Querschnitt, leicht gewölbte Schneide, geschliffen, Länge 8 cm), 14688:76:72 (trapezförmig, geschliffen, Länge 13,8 cm)

Einzelbestattung Bef. 263

- 2 Gefäße, zerscherbt: HK-Nr. 14688:263:1, 14688:263:2

Abb. 19 Döbbelin, Bef. 263. Umzeichnung der Bestattung.

Fig. 19 *Döbbelin, Feature 263. Drawing of the burial.*



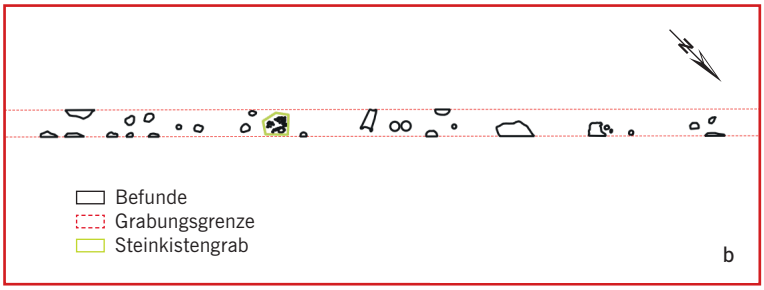


Abb. 20a–b Düsedau, Lkr. Stendal. a Lage der Fundstelle. Der Platz wurde im Zuge eines Radwege-Neubaus angeschnitten und dokumentiert. Die Position der kugelamphorenzeitlichen Bestattung ist mit einem roten Punkt markiert; b Grabungsplan mit Markierung der kugelamphorenzeitlichen Bestattung.

Fig. 20a–b *Düsedau, Stendal district. a Location of the site. It was discovered and documented during the construction of a bicycle path. The position of the burial from the Globular Amphora Culture is marked with a red dot; b excavation plan with the marked burial from the Globular Amphora Culture.*

Düsedau, Lkr. Stendal

Doppelbestattung im Steinkistengrab

Murat Dumlupinarli

Fundplatz	Düsedau
Anlass	Radwegbau entlang der Landesstraße 14 Osterburg–Düsedau
Zeitraum	September 2008 bis Dezember 2008
Aktivitätsnummer	2744 (2. DA)
Grabungsleitung (Projektleitung)	R. Heiner (R. Leineweber)
Topografische Lage	Sporn bzw. Geländekante oberhalb einer Niederterrasse (Uchteniederung; Abb. 20).
Befundart	Steinkistengrab (Innenraum: ca. 1,2 x 0,9 m)
Datierung	Kugelamphorenkultur
Tote	zwei männliche Individuen, linker Hocker (adult/matur)
Literaturverweis	Heiner 2018

Das Steinkistengrab ist in Südost-Nordwest-Richtung ausgerichtet. Es wurde aus unterschiedlich großen Bruchsteinen errichtet, wobei sich im Südosten drei große Gerölle gruppieren. Die südwestliche Seite und westliche Ecke sind stark gestört. In der vermutlich ehemals rechteckigen Kiste sind zwei männliche Individuen in linker Hockstellung mit den Köpfen im Süden und Blick nach Westen beigesetzt (Abb. 21; Heiner 2018). In der Südostecke des Grabes wurden zwei Kugelamphoren und ein weitmündiges Gefäß niedergelegt (Abb. 22). Ein Flintbeil befand sich östlich des Schädels des nördlich gelegenen Individuums, ein weiteres in der südwestlichen Ecke zwischen den Amphoren. In der südöstlichen Ecke befand sich eine weitere Kugelamphore (Abb. 23). Im unteren Brustbereich des südlich gelegenen Individuums wurde eine durchbohrte Bernsteinscheibe platziert (Abb. 24).

In der nur 3 m breiten Radwegtrasse kamen keine weiteren Befunde der Kugelamphorenkultur zutage, lediglich Gruben aus einer jüngeren Siedlungstätigkeit (späte Bronze-/frühe Eisenzeit).

Funde:

Steinkiste: Bef. 24

- 3 Flintbeile: HK-Nr. 2744:25:8 (trapezförmig, leicht gewölbte Schneide, Länge 14 cm, geschliffen), HK-Nr. 2744:25:9 (rechteckiger Querschnitt, leicht gewölbte Schneide, Länge 12 cm), HK-Nr. 2744:25:10 (trapezförmig, Länge 8 cm)

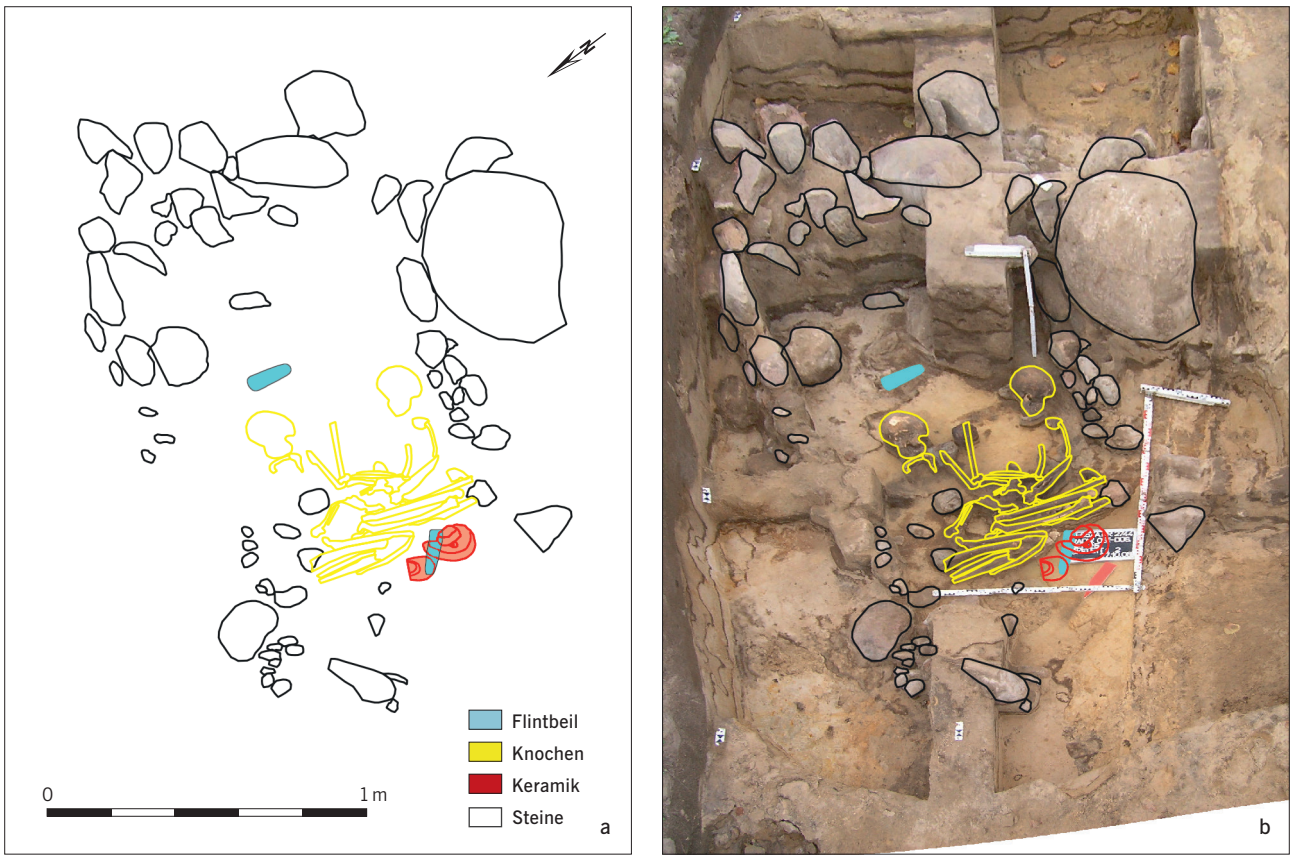


Abb. 21a–b Düsedau, Bef. 24. a Umzeichnung des Steinkistengrabes; b Foto mit Einzeichnung der beiden Individuen und der Beigaben.

Fig. 21a–b *Düsedau, Feature 24. a Drawing of the cist; b photo with the two individuals and the grave goods marked in colour.*

- 3 Kugelamphoren: HK-Nr. 2744:25:3
- 1 weitmündiges Gefäß mit 4 Henkeln auf der Schulter: HK-Nr. 2744:25:4
- 1 Bernsteinscheibe: HK-Nr. 2744:25:5
- 1 Meißel: HK-Nr. 2744:25:11

Abb. 22 Düsedau, Bef. 24. Keramik. 1 Kugelamphore; 2 weitmündiger Topf.

Fig. 22 *Düsedau, Feature 24. Pottery. 1 Globular amphora; 2 wide-mouthed pot.*

Abb. 23 Düsedau, Bef. 24. Flintbeile als Grabbeigaben.

Fig. 23 *Düsedau, Feature 24. Flint axes as grave goods.*

Abb. 24 Düsedau, Bef. 24. Eine Bernsteinperle aus dem Grab.

Fig. 24 *Düsedau, Feature 24. An amber bead from the grave.*

Halberstadt, Lkr. Harz

Eine besondere Bestattung der Kugelamphorenkultur

Jochen Fahr, Anke Herrmann, Susanne Friederich

Fundplatz	Halberstadt-Ost
Anlass	Gewerbegebiet (»NEST«, DaimlerTruck)
Zeitraum	Februar 2023 bis April 2023
Aktivitätsnummer	16553 (2. DA)
Grabungsleitung (Projektleitung)	A. Herrmann, C. Bogen (J. Fahr, S. Friederich)
Osteologische Bestimmung	C. Oelschlägel
Topografische Lage	Im Osten von Halberstadt auf dem Ausläufer eines »Höhenrückens« (Sattel) zwischen zwei Fluss-/Bachläufen (Holtemme, Frevel), mit Blick auf den Brocken und den Huy. In späterer Zeit lag das Areal unmittelbar neben der alten Heerstraße von Halberstadt in Richtung Magdeburg (Abb. 25).
Befundart	Steinkistengrab 1,70 x 0,90 m (Bef. 43), Doppelrinderbestattung (Bef. 408), Opferschacht (Bef. 42)
Datierung	Kugelamphorenkultur
Toter	erwachsener Mann, linker Hocker mit angezogenen Beinen
Literaturverweis	Fahr 2023; Fahr u. a. 2023

Das Steinkistengrab (Bef. 43) war West-Ost ausgerichtet. Ein erwachsenes männliches Individuum wurde in linker Hockerlage mit extrem angewinkelten Beinen bestattet (Abb. 26). Hinter dem Schädel standen zwei unterschiedlich große Kugelamphoren. Im Umfeld des Schädels lagen zudem zwei Schweineunterkiefer, Rinderzähne und ein Knochenpfriem. Ein Flintbeil ohne Gebrauchsspuren wurde in der Nähe der kleineren Amphore deponiert (Abb. 27).

Nordöstlich des Steinkistengrabes befand sich in einem Abstand von ca. 6 m eine ebenfalls West-Ost ausgerichtete trapezförmige Grube (Bef. 408, ca. 2,20 x 1,45 m; Abb. 28). Darin lagen zwei spiegelverkehrt zueinander deponierte Rinder, zwei Schweine und zwei Gefäße. Ein Keramikgefäß stand im mittleren Teil der Grube zwischen den Rindern. Ein zweites Gefäß befand sich im westlichen Teil zwischen Rind und den Hinterläufen eines Schweins.

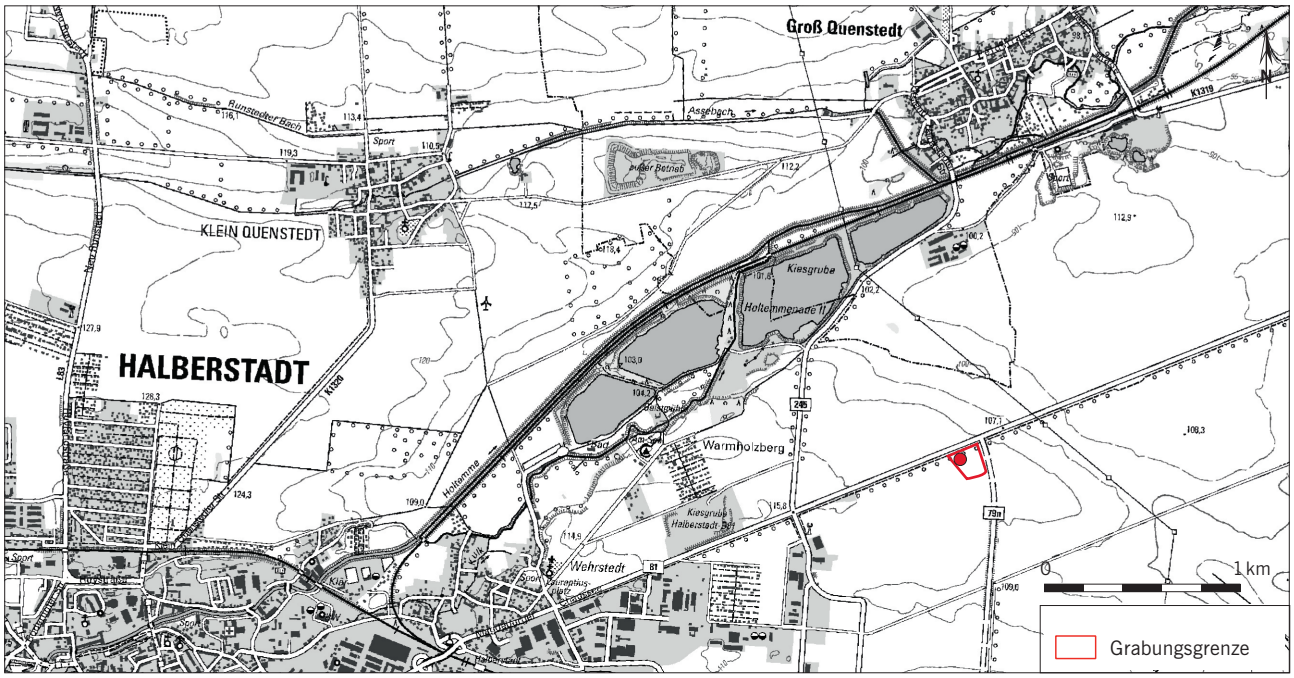


Abb. 25 Lage der Fundstelle Halberstadt, Lkr. Harz. Auf einem Höhenrücken zeigte sich eine mittelneolithische Totenlandschaft u. a. mit einem Steinkistengrab der Kugelamphorenkultur. Unter den zahlreichen Beigaben ist ein zuvor ungenutztes Flintbeil gesondert hervorzuheben.

Fig. 25 *Location of the site at Halberstadt, Harz district. A Middle Neolithic mortuary landscape was discovered on a ridge, including a stone cist burial of the Globular Amphora Culture. Among the numerous grave goods, an unused flint axe deserves special mention.*

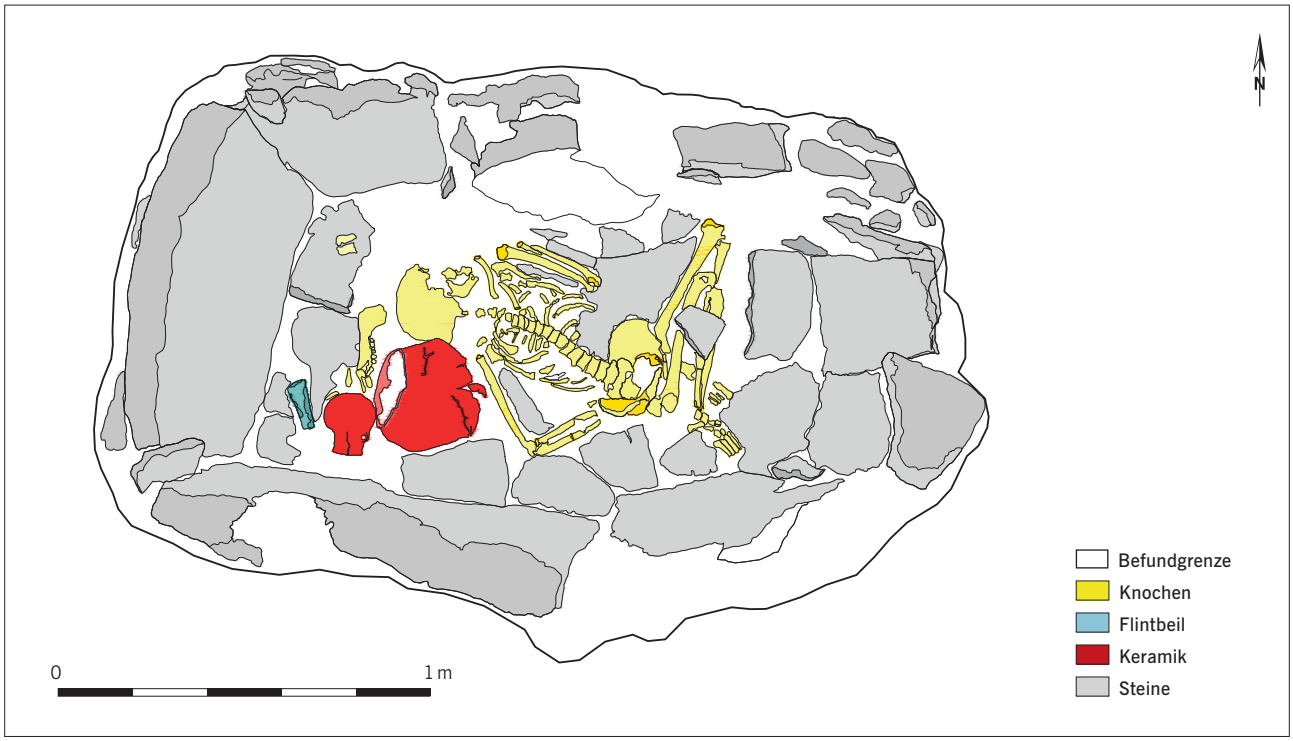


Abb. 26 Halberstadt, Bef. 114. Umzeichnung des Steinkistengrabes.

Fig. 26 *Halberstadt, Feature 114. Drawing of the stone cist burial.*

Etwa 2,50 m nordwestlich des Steinkistengrabes bestand ein Opferschacht (Bef. 42) von max. 2,20 m Tiefe ab heutiger Geländeoberkante (Fahr 2023). Dieser war mit mittelgroßen Sandsteinen und wenigen Kalksteinen abgedeckt (Fahr u. a. 2023). Im Sohlenbereich zeigten sich ein Widderschädel, begleitet von mehreren Rinder- und zwei Hundeknochen. Darüber lagen drei vollständige Hasenskelette und einige Rinderreste. Etwas höher wurde ein Hund zusammen mit wenigen Fragmenten eines Hasen deponiert. Darüber befand sich ein ca. 0,40 m mächtiger Horizont aus umgela-

Abb. 27 Halberstadt, Bef. 43 Das Flintbeil diente als Grabbeigabe.

Fig. 27 *Halberstadt, Feature 43. The flint axe served as a grave good.*

gertem, anstehendem Boden (Löss) und humosem Material ohne Fundgegenstände. Darauf folgten ein vollständiges Rinderskelett sowie als Abschluss unter der Steinpackung vier Rinderschädel und zahlreiche Rinderknochen.

Funde:

Steinkistengrab (Bef. 43)

- Keramikgefäße: HK-Nr. 16553:43:16, 16553:43:28
- Flintbeil: HK-Nr. 16553:43:1 (trapezförmig, leicht gewölbte Schneide, geschliffen, Länge 12,5 cm)
- Silexartefakte: HK-Nr. 16553:43:12a, 16553:43:13a, 16553:43:15a
- Knochenpfriem: HK-Nr. 16553:43:8a
- Tierknochen: HK-Nr. 16553:43:10a, 16553:43:5a, 16553:43:6a, 16553:43:7a, 16553:43:7b, 16553:43:9a

Doppelrinderbestattung (Bef. 408)

- Tierknochen: HK-Nr. 16553:408:1a, 16553:408:10a-31a,33a,35a–43a
- Keramikgefäße: HK-Nr. 16553:408:32a, 16553:408:34a

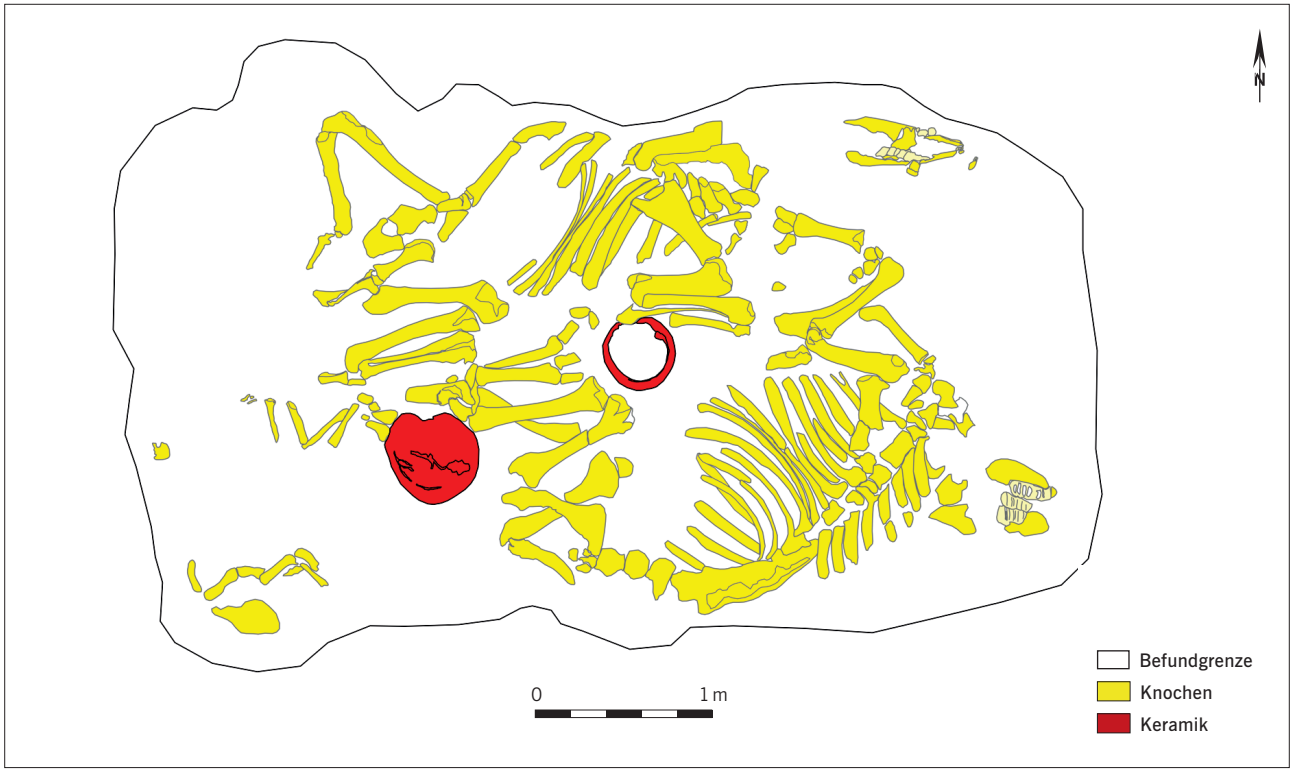


Abb. 28 Halberstadt, Bef. 408. Umzeichnung der Doppelrinderbestattung.

Fig. 28 *Halberstadt, Feature 408. Drawing of a double burial of cattle.*

Abb. 29 Altfund von 1931 von Jerchel, Lkr. Havelland, im Kreismuseum Genthin. Wahrscheinlich Beilausstattung einer Bestattung der Kugelamphorenkultur; o. M.

Fig. 29 *Old find from 1931 from Jerchel, Havelland district, at the District Museum Genthin. Probably axe equipment from a burial of the Globular Amphora Culture; no scale.*

Jerchel, Lkr. Havelland

Jonas Beran

Fundplatz	Fpl. 4, ehemalige Sandgrube am östlichen Ortsrand, Flurbezeichung »Die Schweiz«
Anlass	Sandabbau
Zeitraum	Mai und Juli 1931
Finder	Schulkinder und Dorfschullehrer (von 1913–1952) W. Volkmann, sichergestellt von O. Vogeler, Kreismuseum Genthin
Topografische Lage	Sandinsel im Elbe-Urstromtal, am Südwestrand der Havelniederung
Befundart	Gestörtes Körpergrab
Datierung	Kugelamphorenkultur
Literaturverweis	Kirsch 1993

Eine erstaunliche Übereinstimmung mit der Beigabenausstattung des Dahlener Grabes zeigt ein 1931 in Jerchel geborgenes Fundensemble (Abb. 29). Der Fundort gehörte bis 1952 zum Landkreis Jerichow II, daher befindet es sich im Kreismuseum Genthin. Fundplatz ist eine Sandgrube am östlichen Ortsrand.

Zu einem großen, dem Dahlener stark ähnelnden Flintbeil kommen zwei mittelgroße, ein aus einem Meißel hergestellter Feuerschläger sowie ein typischer komplett geschliffener Meißel und eine kleinere verzierte Schale.

Sehr gut dazu passen würde ein größeres Grünsteinbeil, allerdings soll es von einem anderen Fundplatz westlich des Ortes stammen. Aufgrund von widersprüchlichen Fundplatzangaben war eine Zusammengehörigkeit von E. Kirsch (1993, 305 Nr. 1244 und 1245) nur erwogen und das rekonstruierte Gefäß und der Feuerschläger abgebildet worden.

Die Zusammengehörigkeit kann aber nach Recherchen von Museumsleiterin Antonia Beran anhand von noch in Genthin vorhandenen Postkarten vom 6. Juni und 22. Juli 1931, die der Finder Lehrer Walter Volkmann an den damaligen Museumsleiter Otto Vogeler geschrieben hatte, einigermaßen wahrscheinlich gemacht werden:

»Heute brachten mir die Kinder ein wunderbares Steinbeil, Feuerstein, exacte, beschliffene Form, 12 cm lang, 3½ cm saubere Schneide; da kannst Du Schinken mit schneiden. Möchtest Du das Ding haben, oder hast Du schon genug solche Dinger?« (Kreismuseums Jerichower Land, Genthin, OA Jerchel).

»Heute soeben einen prächtigen Fund gemacht, an gleicher Stelle, wo das von Dir geholte Steinbeil gefunden wurde. Ein Junge brachte mir von dort wieder ein 3 cm schmales 11 cm langes, 1½ cm dickes ebenso sauber bearbeitetes Meißelchen. Nun grub ich vorsichtig nach, fand einzelne Urnenscherben einer zerdrückten Urne; schön verzierte Ränder u ein Bodenstück rettete ich für Dich. Unter dem Boden lag ein prächtiges großes Steinbeil derselben Arbeit, Schneide 8 cm, Länge fast 20 cm, sauber bearbeitet, vom selben Stein, wie beim ersten Fund.« (Kreismuseum Jerichower Land, Genthin, OA Jerchel).

Die Zusammengehörigkeit des großen und eines kleineren Flintbeiles, des Meißels und des Gefäßes erscheinen damit gesichert. Dass ein weiteres Flintbeil und ein aus einem Flintmeißel – ähnlich wie in Dahlen – umgearbeiteter Feuerschläger vom selben Fundplatz stammen, ist sehr wahrscheinlich.

Das Grünsteinbeil gehört »nach Aktenlage« eher nicht dazu, aber es könnten hier auch ein Versehen oder eine frühere Verschleppung vorliegen, was bislang spekulativ ist, aber nicht unerwähnt bleiben soll.

Funde im Kreismuseum Jerichower Land in Genthin

- 1 dicknackig, dünnblattiges Flintbeil mit rechteckigem Querschnitt, Breitseiten nahezu komplett, Schmalseiten nicht geschliffen, glänzend poliert, keine Gebrauchsspuren, Länge 20 cm, Schneidenbreite 7,8 cm, Dicke 2,2 cm: Inv.-Nr. 31:4
- 1 dicknackig, dünnblattiges Flintbeil mit rechteckigem Querschnitt, Breitseiten nahezu komplett, Schmalseiten nicht geschliffen, Schneidenbereich glänzend poliert, keine Gebrauchsspuren, Länge 11,7 cm, Schneidenbereite 5 cm, Dicke 2 cm: Inv.-Nr. 0176
- 1 dicknackiges, dünnblattiges Flintbeil mit rechteckigem Querschnitt, Breitseiten großen Teils, Schmalseiten nicht geschliffen, Schneide glänzend poliert, an der Schneide leichte Gebrauchsspuren, Länge 11,5 cm, Schneidenbereite 3,7 cm, Dicke 1,3 cm: Inv.-Nr. 039
- 1 Flintmeißel, allseitig geschliffen, Länge 11,5 cm, Breite 1,8 cm, Dicke 1,5 cm: Inv.-Nr. 040
- 1 aus einem geschliffenen Flintmeißel sekundär umgearbeiteter Feuerschläger, Länge 6,9 cm, Breite 1,8 cm, Dicke 1,2 cm: Inv.-Nr. 0114
- 1 Felsgesteinbeil mit rechteckigem Querschnitt aus grobkörnigem granitoiden Gestein, Schneide alt beschädigt, Länge 14,6 cm, Breite 5,8 cm, Dicke 4,2 cm: Inv.-Nr. 0170
- 1 rundbodige Schale mit Bogenstichverzierung, aus Scherben geklebt und mit Gips ergänzt, Höhe 10,5 cm, Mündungsdurchmesser 15–16 cm: Inv.-Nr. 061

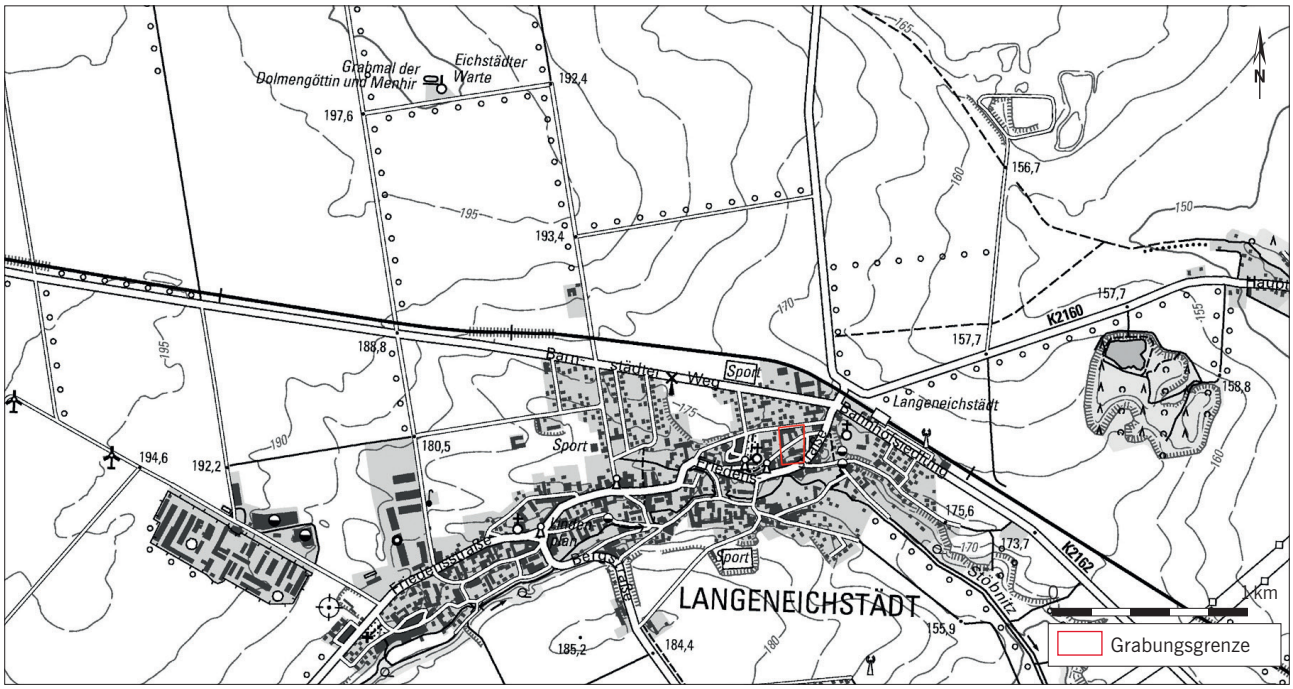


Abb. 30 Lage der Fundstelle Niedereichstädt, Saalekreis.

Fig. 30 *Location of the site at Niedereichstädt, Saalekreis district.*

Niedereichstädt, Langeneichstädt, Saalekreis

Steinkammergrab mit drei Bestattungen

Murat Dumlupinarli

Fundplatz	Niedereichstädt
Anlass	Nachforschung
Zeitraum	1864
Grabungsleitung	T. Scheppe
Anthropologische Bestimmung	
	Dr. Viedeband
Topografische Lage	Hanglage (Abb. 30)
Befundart	Steinkammergrab (3,20 x 1,30 m) mit Eingang
Datierung	Kugelamphorenkultur
Tote	zwei Männer, ein Mädchen (juvenil)
Literaturverweis	Beier 1988; Bleicher u. a. 2006

Das Grab ist in Nord-Süd-Richtung ausgerichtet. Die Steinkammer ist rechteckig aufgebaut. Die Wände sind jeweils gleich hoch, sodass das Grab mit horizontalen Steinplatten verschlossen werden konnte. Der Eingang lag im Süden und war durch mehrere hintereinander angeordnete Steinplatten gebildet, die zusätzlich durch kleinere Steine gestützt oder abgedichtet wurden. Der Vorraum war etwa 1,3 m lang. Der Übergang zur Hauptkammer war durch eine Platte abgeschlossen, die jedoch nicht breit genug war, um den Eingang allein zu bedecken (Beier 1998, 130). Eine Eichenbohle wurde zu diesem Zweck an die Seite gestellt (Beier 1998, 130).

An den nördlichen und südlichen Enden wurden jeweils zwei männliche Individuen einzeln niedergelegt. In der Mitte, auf einer Eichenbohle, war ein etwa 14 Jahre altes Mädchen beigesetzt (Beier 1998, 130). Im Bereich des Schädels standen drei Kugelamphoren (Abb. 31) und in der Kammer fanden sich zahlreiche durchbohrte Tierzähne verteilt.

Funde im Leibniz-Zentrum für Archäologie Mainz (ehemals Römisch-Germanisches Zentralmuseum)

Steinkammergrab[18]**:**

- 1 Kugelamphore am Hals eingeritzter Winkellinien und Rauten: Inv.-Nr. 0.355
- 2 Flintbeile: eines mit Holzschäftung aus Birkenholz ca. 50 cm lang, geschliffen, schwarz: Inv.-Nr. 0.357
- Feuersteinklinge: Inv.-Nr. 0.363
- Schild? aus dünnen Brettern, die zusammengeheftet und mit Bast verbunden sind: Inv.-Nr. 0.358
- Tierknochen: 31 durchbohrte Hund-/Schweinezähne und Eberhauer: Inv.-Nr. 0.356
- Bernstein: Inv.-Nr. 0.361
- Steinperle: Inv.-Nr. 0.360
- Kupferröllchen: Inv.-Nr. 0.359

18 Fundstellenarchiv, LDA Halle, ID 2005, OA Langeneichstädt, Bl. 52.

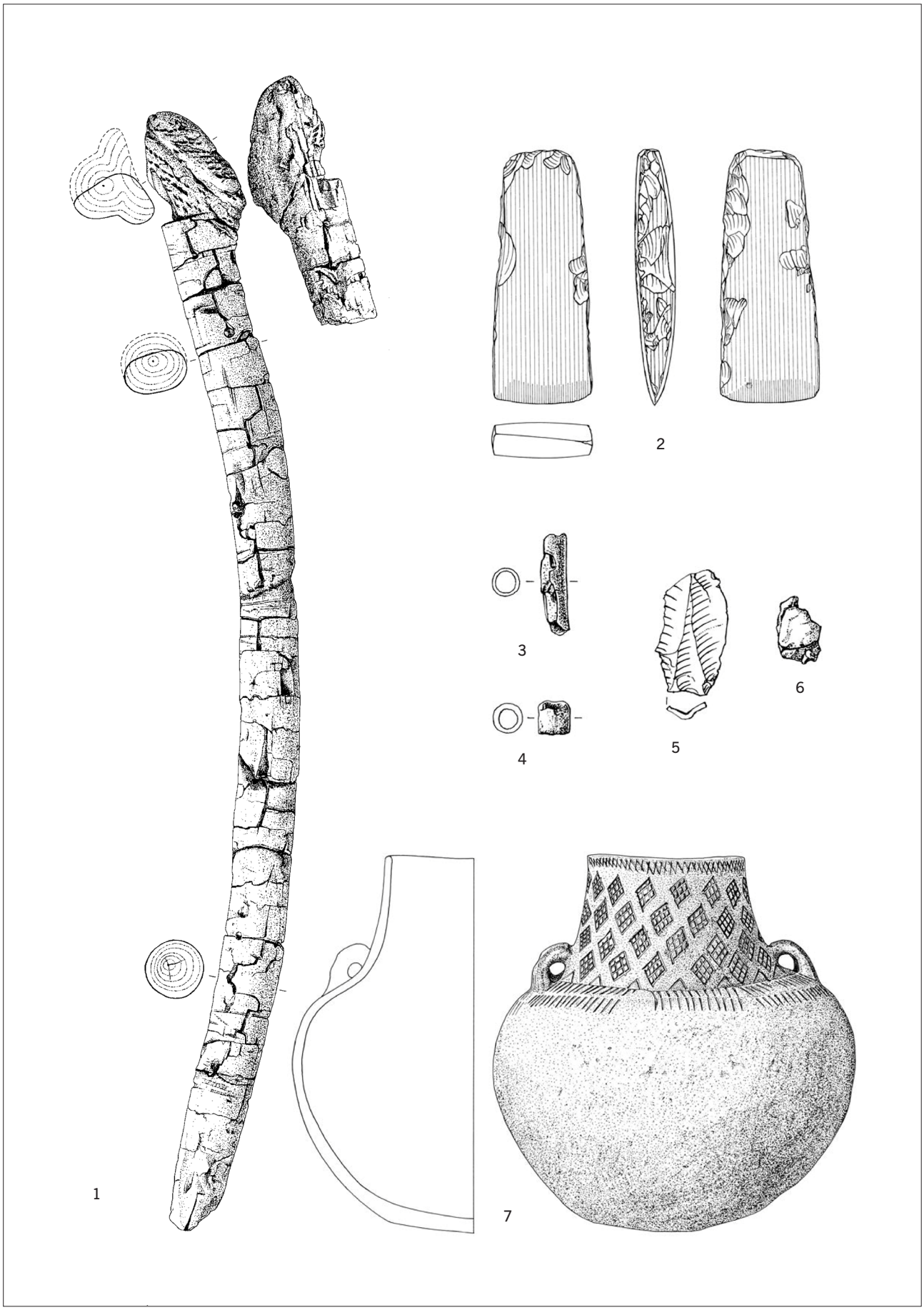


Abb. 31 Niedereichstädt. 1 Holzschäftung aus Birkenholz; 2 Flintbeil; 3 Kupferröllchen; 4 Steinperle; 5 Silexklinge; 6 Bernstein; 7 Kugelamphore.

Fig. 31 *Niedereichstädt. 1 Birchwood shaft; 2 flint axehead; 3 small copper cylinders; 4 stone bead; 5 silex blade; 6 amber; 7 globular amphora.*

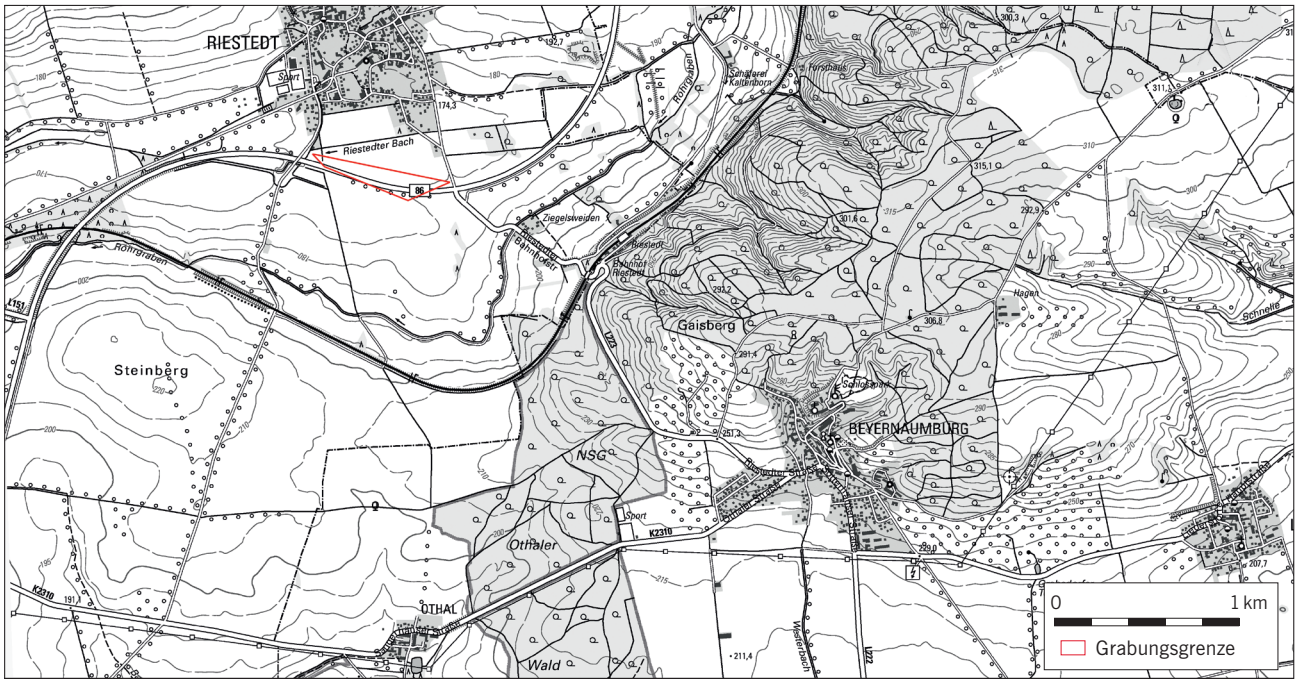


Abb. 32 Lage der Fundstelle »Die Aue«, Riestedt, Lkr. Mansfeld-Südharz. Der Platz wurde im Zuge eines Straßenneubaus angeschnitten.

Fig. 32 *Location of the site at »Die Aue«, Riestedt, Mansfeld-Südharz district. The site was discovered during road construction.*

Riestedt »Die Aue«, Lkr. Mansfeld-Südharz

Das Kindergrab von Riestedt

Murat Dumlupinarli

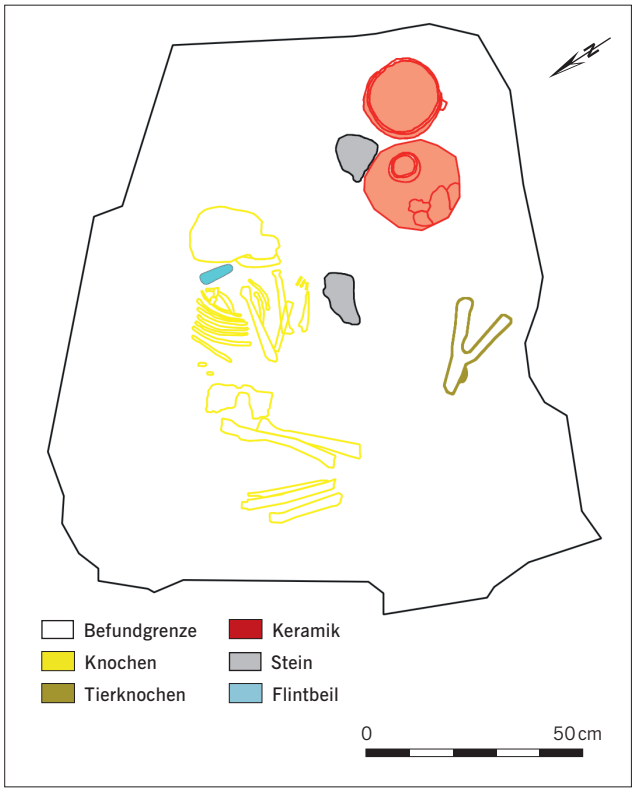


Abb. 33 Riestedt, »Die Aue«. Umzeichnung des Steinkistengrabes.

Fig. 33 *Riestedt, »Die Aue«. Drawing of the stone cist burial.*

Fundplatz	Riestedt »Die Aue«
Anlass	Straßenbau OU Riestedt B 80/B 86
Zeitraum	August 2001 bis September 2001
Aktivitätsnummer	13201 (Notbergung)
Grabungsleitung (Projektleitung)	M. Zemann-Wahle (A. Reichenberger)
Osteologische Bestimmung	H.-J. Döhle
Anthropologische Bestimmung	R. Schafberg
Topografische Lage	Die Fundstelle Aue befindet sich in leichter Hanglage; das Gelände neigt sich sanft in östlicher Richtung (Abb. 32).
Befundart	Steinkistengrab (Innenraum: 1,40 x 0,95 m) und Begleitgrube mit Niederlegung eines Rindes
Datierung	Kugelamphorenkultur
Toter	Kind, 6–7 Jahre alt (Infans II), in linker Hockerlage mit angezogenen Beinen und Armen. Kopf im Osten, Blick nach Westen. Das Kind ist an einer schweren Infektionskrankheit in Kombination mit einem Wasserkopf *(Hydrocephalus externus)* verstorben (Döhle u. a. 2002).
Literaturverweis	Döhle u. a. 2002

Das rechteckige, Nordwest-Südost ausgerichtete Steinkistengrab war mit Rogensteinen und Zechsteinkalk-Bruchstücken ausgekleidet und mit einer Rogensteinplatte abgedeckt. Darin wurde das Kind in linker Hockerlage beigesetzt (Abb. 33). In der Nordostecke befand sich ein weitmündiger

Abb. 34 Riestedt, »Die Aue«. Keramik. 1 Kugelamphore; 2 weitmündiger Topf; 3 Schale.

Fig. 34 *Riestedt, »Die Aue.« Pottery. 1 Globular amphora; 2 wide-mouthed pot; 3 bowl.*

Topf (Abb. 34,2). An der südwestlichen Ecke war eine Kugelamphore mit zwei gegenständigen Henkelösen (Abb. 34,1) platziert, direkt daneben eine Schale (Abb. 34,3). In der Südwestecke überdeckte der Unterkiefer eines weiblichen Schweines einen Eberhauer. Im Bereich der Wirbelsäule bzw. des linken Schulterblattes lag ein Flintbeil (Abb. 35). Eine aus durchlochten Hirschgrandeln gefertigte Kette lag unter dem Schädel (Abb. 36).

Südöstlich des Steinkistengrabes befand sich in einem Abstand von 1,80 m eine gleichfalls Nordwest-Südost ausgerichtete Grube (3,50 x 1,50 m). Darin war ein Rind niedergelegt worden.

Funde:

Steinkiste Bef. 127

- 1 Kugelamphore: HK-Nr. 13201:127:42
- 1 weitmündiger Topf: HK-Nr. 13201:127:41

Abb. 35 Riestedt, »Die Aue«. Flintbeil aus einem Grab.

Fig. 35 *Riestedt, »Die Aue.« Flint axe from a grave.*

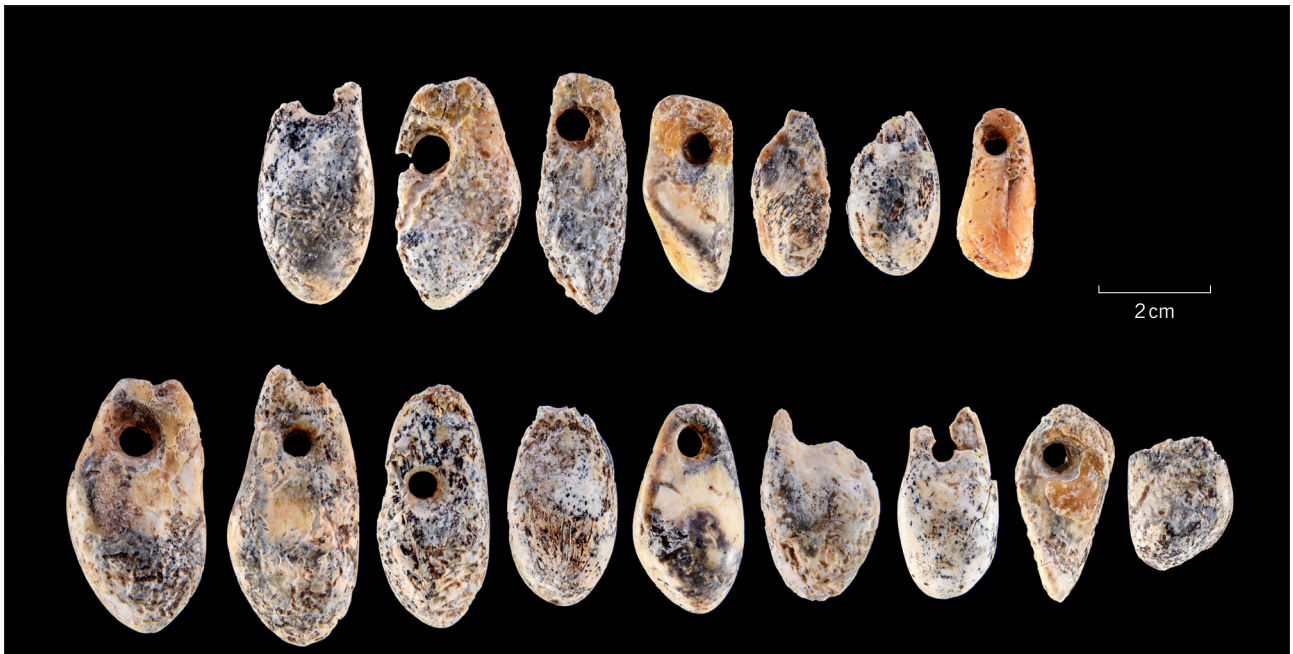


Abb. 36 Riestedt, »Die Aue«. Hirschgrandeln fanden sich ebenfalls in einem Grabzusammenhang.

Fig. 36 *Riestedt, »Die Aue«. Red-deer upper eyeteeth from a grave context.*

- 1 Schale: HK-Nr. 13201:127:43
- 1 Flintbeil: HK-Nr. 13201:127:40 (trapezförmig, leicht gewölbte breite Schneide, geschliffen, Länge 12 cm)
- Silexabschlag: HK-Nr. 13201:127:45
- 16 Hirschgrandeln: HK-Nr. 13201:127:47
- Unterkiefer (weibliches Schwein, 15–18 Monate): HK-Nr. 13201:127:48
- Eberhauer: HK-Nr. 13201:127:44

Rindergrube Bef. 126
- 1 Rind (4 Jahre)

Westerhausen, Lkr. Harz

Steinkistengrab mit einer Menschenbestattung und zwei Gruben mit 5 bzw. 2 Rindern

Murat Dumlupinarli

Fundplatz	Westerhausen (Fundstelle III Ost)
Anlass	Straßenneubau B 6n, PA 8-1
Zeitraum	März 2003 bis September 2003
Aktivitätsnummer	556 (2. DA)
Grabungsleitung (Projektleitung)	J. Pape, H. Schmidt, C. Steinmann (V. Dresely)
Osteologische Bestimmung	H-J. Döhle
Anthropologische Bestimmung	F. Jakobi
Topografische Lage	Die Fundstelle III Ost liegt zwischen Westerhausen und Börnecke. Sie kann in zwei Teile aufgeteilt werden: einen westlichen Teil mit stärkerer Hanglage und einen flach auslaufenden Ostteil (Döhle/Pape 2021, 355). Die auffällige Kuppe zwischen den Felsformationen des Breit- und Jätchenberges wird im Nordosten durch harte Quarzit-Sandsteine begrenzt und im Südwesten durch Sandsteine der Involutus-Schichten (Abb. 37).
Befundart	Steinkiste und zwei Gruben mit zwei bzw. fünf Rinderskeletten; alle Befunde in gleicher Nordwest-Südost-Ausrichtung.
Datierung	Kugelamphorenkultur
^{14}C-Datierung	3040–2840 cal BC[19] (Steinkiste); 2880–2620 cal BC[20] Rind aus Bef. 3074
Größe der Steinkiste	2,00 x 1,17 m (Innenraum)
Toter	adulter Mann, jünger als 40 Jahre (aufgrund schlechter Knochenerhaltung keine exakte anthropologische Ansprache möglich). Linker Hocker mit angezogenen Beinen. Kopf im Osten, Blick nach Westen (Abb. 38).
Literaturverweis	Döhle/Pape 2006; Döhle/Pape 2021

19 Erl-8208: 4286 ± 62 BP (1σ 2790–2660 cal BC, 2σ 3040–2840 cal BC).

20 KIA 23660: 4158 ± 30 BP (1σ 2790–2660 cal BC, 2σ 2880–2620 cal BC).

Abb. 37 Lage der Fundstelle Westerhausen, Lkr. Harz. Der Platz wurde im Zuge eines Straßenneubaus der B 6n angeschnitten und dokumentiert. Die Position der kugelamphorenzeitlichen Bestattung ist mit einem roten Punkt markiert.

Fig. 37 *Location of the site at Westerhausen, Harz district. The site was discovered and documented during the construction of federal road B 6n. The position of the burial from the Globular Amphora Culture is marked with a red dot.*

Während der Bernburger Kultur bestand am Osthang des Jätchenbergs ein eingehegter Siedlungsplatz. Dieser Platz dürfte bereits aufgegeben worden sein, als in der Zeit der Kugelamphorenkultur ein reich ausgestattetes Steinkistengrab und zwei zugehörige Gruben mit insgesamt sieben deponierten Rindern angelegt worden waren. Obgleich nur ein schmaler Trassenkorridor von 9600 m² untersucht wurde, dürfte der Jächtenberg zur Zeit der Kugelamphorenkultur nur für das Bestattungsensemble genutzt worden sein. Während der späten Bronzezeit bzw. frühen vorrömischen Eisenzeit wurde das Gelände erneut besiedelt.

Das Steinkistengrab ist in Ost-West-Richtung ausgerichtet und war mit zwei bis zu 600 kg schweren Sandsteinplatten abgedeckt worden, an deren Rändern und in Zwischenräume kleinere Rogensteine gesetzt wurden (Döhle/Pape 2006, 83). Die Deck- und Sandsteinplatten wurden vor Ort beschafft, während die Rogensteine für die Zwischenräume über eine Entfernung von 8 km vom nordöstlichen Harzrand nach Westerhausen herbeigeschafft wurden (Döhle/Pape 2021, 357).

In der Steinkiste wurde ein männliches Individuum in linker Hockerlage niedergelegt (Abb. 39). Eine Kugelamphore mit Öffnung nach unten wurde über dem Becken positioniert, eine zweite, etwas kleinere Amphore stand neben dem Oberschenkel; in der Nordwestecke wurde eine Schale mit Henkeln abgelegt (Abb. 40). Ein Flintbeil befand sich unter dem rechten Oberarm, ein weiteres in der südlichen Ecke neben der kleineren Amphore. Ein Röhrenknochen und ein Unterkiefer eines Ebers lagen in der Südwestecke. Am rechten Unterschenkel befand sich ein schlecht erhaltener Geweihhammer (Fußbereich, Nordwestecke des Grabes). Auf beiden Seiten des Schädels lagen jeweils zu einer Kette aufgefädelte durchbohrte Schneckengehäuse.

An das Steinkistengrab anschließend, befanden sich in einem Abstand von 1,5 m zwei Gruben mit Rinderniederlegungen; sie hatten die gleiche Ausrichtung wie das Steinkistengrab. In der quadratischen größeren Grube lagen fünf Rinderskelette; alle in Bauchlage mit angewinkelten Extremitäten; Köpfe wiesen nach Osten–Südosten (Abb. 41). Es handelt sich um drei jungerwachsene Stiere, einen älteren Stier und eine erwachsene Kuh (Döhle/Pape 2021, 363). In der kleineren Grube befanden sich zwei jungerwachsene Rinder (Stier und vermutlich Kuh) in seitlicher Lage mit stark angewinkelten Extremitäten. Der Schädel des im Süden niedergelegten Stieres war um fast 90° nach Nordnordost gedreht; in seinem Halsbereich steckte noch das Tötungswerkzeug, eine Knochenspitze (Döhle/Pape 2021, 364). Alle sieben Rinder – im besten Alter, gesund und mit für neolithische Rinder in Mitteldeutschland typischen Widerristhöhen – wurden demnach speziell für die Beisetzung getötet (Döhle/Pape 2021, 365).

Funde:

Steinkiste Bef. 3091

- 2 Kugelamphoren: HK-Nr. 2003:12128, 2003:12162
- 1 weitmündiges Gefäß mit 4 Henkeln auf der Schulter: HK-Nr. 2003:12129
- 2 Flintbeile: HK-Nr. 2003:121512 (rechteckiger Querschnitt, leicht gewölbte Schneide, auf der Breitseite teilweise angeschliffen, Länge 14 cm) und HK-Nr. 2003:12161 (rechteckiger Querschnitt, leicht

Abb. 38 Westerhausen. Befundfoto der Steinkiste mit farblicher Einzeichnung des Individuums und der Beigaben.

Fig. 38 *Westerhausen. Feature photo of the stone cist burial with the position of the individual and grave goods marked in colour.*

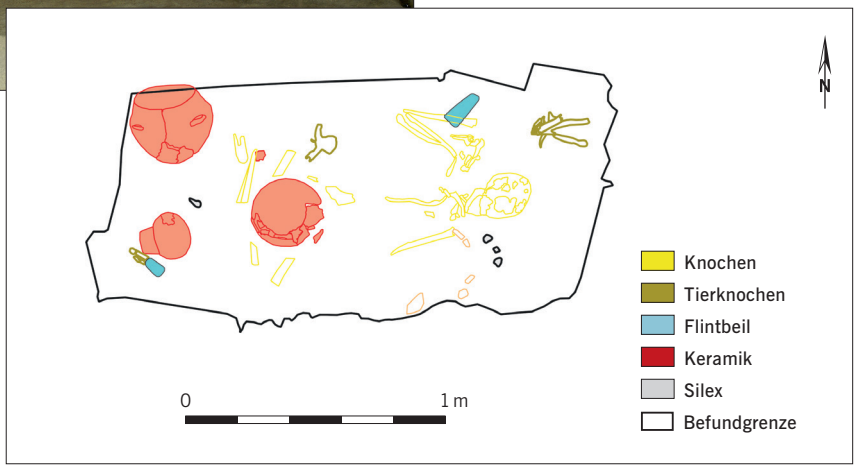


Abb. 39 Westerhausen. Umzeichnung des Steinkistengrabes.

Fig. 39 *Westerhausen. Drawing of the stone cist burial.*

Abb. 40 Westerhausen. Beigabenensemble aus Keramik und Flintbeilen; o. M.

Fig. 40 *Westerhausen. Grave goods inventory of pottery and flint axes; no scale.*

gewölbte Schneide, Länge 10 cm. Gröber gearbeitet als HK-Nr. 2003:121512)
- 1 Klingenfragment: HK-Nr. 2003:12150
- 2 Abschläge: HK-Nr. 2003:12149, 2003:12151
- 1 Hirschgeweihhammer: HK-Nr. 2003:12160; zur Verstärkung der abgesägten Arbeitsfläche wurde ein Rinderzahn eingetrieben.
- Unterkiefer eines Ebers mit Hauern: HK-Nr. 2003:12153
- 2 Ketten aus durchbohrten Schnecken

Rindergrube I Bef. 3074
- 5 Rinder (4 Stiere [3 x 2,5–3,5 Jahre, 1 x 8–10 Jahre], 1 Kuh [5–7 Jahre])

Rindergrube II Bef. 3075
- 2 Rinder (1 Stier [4 Jahre], 1 Kuh [3 Jahre?])
- Knochenspitze: HK-Nr. 2003:11991
- 2 Scherben von Kugelamphoren: HK-Nr. 2003:11992
- Weitmündiges Gefäß: HK-Nr. 2003:11990

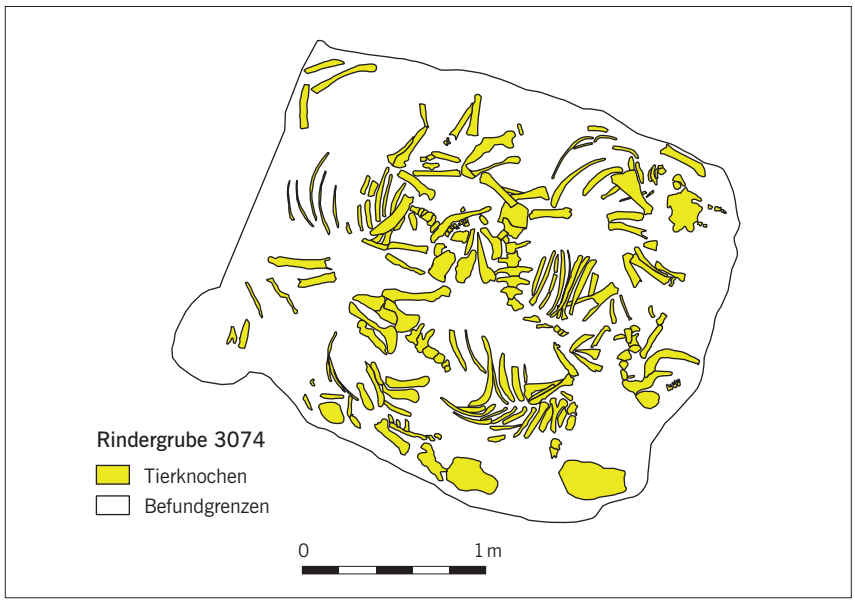


Abb. 41 Westerhausen, Bef. 3074. Umzeichnung der Rindergrube.

Fig. 41 *Westerhausen, Feature 3074. Drawing of the pit containing cattle.*

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Neolithic axe production in Central Germany: A first approach to technological aspects and lithic raw materials

Simone Meinecke, Roberto Risch, Laura Culí Verdaguer, and Francisco José Martinez Fernandez

Zusammenfassung

Neolithische Beilproduktion in Mitteldeutschland: ein erster Ansatz zu technologischen Aspekten und lithischen Rohmaterialien

Beile und Dechseln aus unterschiedlichen Arten von grünlichem Gestein wurden in Mitteleuropa seit dem Mesolithikum verwendet. Das Gestein – oft fälschlich als Amphibolit bezeichnet – wurde zu Werkzeugen zur Holzverarbeitung oder zum Schlachten und zu Waffen verarbeitet und diente vermutlich auch als Tauschmittel. Wenngleich die Typologie dieser Artefakte mehr oder weniger gut definiert ist, fehlt es bisher an umfassenden Untersuchungen zu Herkunft und Herstellungsprozessen.

Ein kollaboratives interdisziplinäres Forschungsprojekt des Landesamts für Denkmalpflege und Archäologie Sachsen-An-halt und der Universitat Autònoma de Barcelona zielt darauf ab, neue Erkenntnisse zu den Rohmaterialquellen in Mitteleuropa zu gewinnen. Die bisherige Untersuchung von Herstellungsspuren an mehr als 350 Beilen aus Sachsen-Anhalt und Sachsen umfasst archäometrische, morphologische und technologische sowie petrografische und geochemische Analysen. Dies ermöglichte die Identifizierung zahlreicher frühneolithischer Werkstätten zur Beilherstellung in Mitteldeutschland, in denen eine besondere Art von Grünschiefer verarbeitet wurde. Petrografisch ähnelt dieses Gestein dem bekannten Metabasit, der während des Frühneolithikums im Isergebirge, Nordböhmen (Tschechische Republik) abgebaut wurde. Die Sägetechnik in der Frühstufe des Herstellungsprozesses vieler mitteldeutscher Beil- und Axtklingen wurde in den Werkstätten von Jizera jedoch nicht angewendet. Dort wurde Grünschiefer durch Schlagtechnik bearbeitet.

Das häufige Auftreten von Sägespuren an Rohlingen und Beilen aus den Siedlungen und Hortfunden sowie die Anzahl an Werkstätten in Mitteldeutschland lassen Zweifel an den Metabasit-Steinbrüchen des Isergebirges als einzige neolithische Rohstoffquelle für Mitteleuropa aufkommen. Die ersten Forschungsergebnisse weisen vielmehr auf die Existenz weiterer Gewinnungszentren für Rohmaterialien hin. Die vorliegende Untersuchung bestätigt zudem die abnehmende Bedeutung von Grünschiefer im Mittel- und vermutlich Spätneolithikum, als man begann, andere lokale Gesteinsarten aus sekundären klastischen Sedimenten zu gewinnen.

Schlagwörter neolithische Steinbeile, Herstellungstechniken, Austauschnetzwerke, variszischer Grünschiefer, Zentraleuropa

Summary

Stone axes and adzes made from various types of greenstones have been used in Central Europe since the Mesolithic. These rocks – often incorrectly labelled as amphibolite – were processed into tools for woodworking and butchering and into weapons, and they probably also served as exchange values. While their typology is more or less well defined, their provenance and manufacturing processes still lack comprehensive studies.

A collaborative interdisciplinary research project between the State Office for Heritage Preservation and Archaeology of Saxony-Anhalt and the Universitat Autònoma de Barcelona aims to bring new insights into the field of lithic raw material sources in Central Europe. The investigation of over 350 axe manufacturing remnants from Central Germany included archaeometrical, morphological, and technological studies, as well as petrographic and geochemical analysis. As a result, a large number of Early Neolithic axe production workshops could be identified in Central Germany, where a specific type of green schist was processed. In petrographic terms, this rock strongly resembles the well-known metabasite quarried during the Early Neolithic in Jizera, Northern Bohemia (Czech Republic). However, the technique of sawing, used during the early stages of the manufacturing process of many of the Central German axeheads, was uncommon in the workshops on the Czech quarry site, where flaking appears to have been the dominant technique.

The abundance of rock slabs with sawing traces, axe blanks, and manufacturing remnants in the settlements and hoards of Central Germany as well as the technological differences in the axe production techniques used in the workshops call into question whether the metabasite quarries in Jizera were the only raw material source for Central Europe during the Neolithic; the evidence points towards the existence of additional regional raw material production centres. The present study also confirms the decreasing importance of actinolite-hornblende-schist during the Middle and, probably, Late Neolithic, when other types of local rocks started to be obtained from secondary clast deposits.

Keywords Neolithic stone axes, production techniques, exchange networks, Variscan greenschist, Central Europe

Introduction

Stone axeheads offer one of the main archaeological indications of economic development from the Early Neolithic (5500–3950 BC) to the Bronze Age (2200–750 BC), when they were gradually substituted by copper and bronze equivalents, as G. Clark argued over 50 years ago (1965). They are one of the few archaeological materials that, in principle, offer the possibility to trace the whole economic cycle from the exploitation of the rocks in quarries or secondary deposits to the manufacturing spaces revealed by axe blanks and production debris, to their final use or loss in domestic contexts, fields, and natural spaces, as well as in intentionally created hoards and burials.

While economically oriented research on stone axeheads has been notable in Western Europe[1], the situation in Central and Eastern Europe shows a very uneven picture. Excellent petrographic studies of stone axes opened the first and third issues of the well-known »Jahresschrift für die Vorgeschichte der sächsisch-thüringischen Länder« (Luedecke 1902; Luedecke 1904), and notable research has recently been performed by Czech and Polish researchers to identify and investigate the Neolithic quarry sites in the Jizera Mountains (Šrein et al. 2002; Prostředník et al. 2005; Šída 2009), but geoarchaeological and technological studies are still relatively limited and discontinuous in most regions[2]. Functional analyses have not been performed.

The present consensus concerning Neolithic axe production and circulation in Central Europe seems to be that most tools made from metabasite derived from quarries in the Jizera Mountains near Jistebsko, Jablonec nad Nisou district, where Early Neolithic quarrying is well documented[3]. However, this view overlooks the fact that, from early on, some researchers – most of them working in the former German Democratic Republic (GDR) and Czechia – pointed out a relative abundance of half-finished axeheads, axe blanks, and even rock slabs with sawing traces in Central Germany[4]. A study of the axes of the archaeological collection of the Friedrich Schiller University Jena has again revealed the abundance of these manufacturing remains, particularly in the area of the middle Saale and Unstrut Rivers (Martin 2020). The most eastern find spot of axe blanks in Germany is Dresden-Nickern (Baumann 1962), in Central Saxony, whereas there is a lack of such remains further east until we reach the Jizera region, c. 120 km further east as the crow flies. Consequently, considering the distribution pattern of the evidence of manufacturing alone already raises doubts concerning an exclusive provenance of Neolithic axeheads from the Northern Bohemian Variscan outcrops. The insight gained so far from axe manufacturing in Western Europe suggests that raw materials were usually processed in the region surrounding the exploited quarries or secondary deposits and that axe blanks rarely circulated beyond distances of c. 40 km[5], which is significantly less than the distance between the Saale-Unstrut manufacturing area and the Jizera quarries (> 200 km). Only in the case of the exceptionally resistant and hard Alpine jadeitite and eclogite or the dolerite of the Neolithic Sanganakallu quarries, state of Karnataka, in Central India, raw materials circulated across distances of up to 100 km, and occasionally even over 200 km (Pétrequin et al. 2012; Pétrequin et al. 2017; Risch et al. 2011, 200).

A second element of doubt towards the dominant interpretation arises from the technological study of the blanks in both regions. While the studies published so far on Jizera show that the raw material was processed predominantly by flaking (Šída 2009; Šída 2014), the characteristic working traces of the Saale-Unstrut slabs and blanks are the result of intense, mostly lengthwise sawing[6].

Consequently, archaeological criteria alone strongly question the provenance of the majority of Neolithic axes of Central Europe from the Jizera quarry sites. More probably one or several raw material sources must have existed near the Saale-Unstrut region. In this sense, it might be worth recalling the already mentioned petrographic analysis of the mineralogist O. Luedecke (1902; Luedecke 1904). He pointed out that a possible source of the dominant hornblende schist might have been the crystalline complex of Ruhla, Wartburgkreis district, in Thuringia. However, he also noted that the mineralogical composition of the hornblende rocks in Ruhla is different from that observed along the sectioned axes, and its mineral size is larger (Luedecke 1902, 9–10). Following Luedecke's idea of a local raw material source, numerous researchers have suggested that the Harz Mountains (Saxony-Anhalt), or the Thuringian crystalline complexes (Kyffhäuser crystalline complex, Thuringian Forest, including the Ruhla crystalline complex), or the Thuringian Highlands, or the Fichtelgebirge (Bavaria), or the Saxonian crystalline complexes (Ore Mountains, Frankenberg-allochthonous unit), or even the Spessart (Hesse) were the provenance areas for the dominant hornblende schist[7], but comprehensive geoarchaeological studies of these possible provenance areas are lacking.

Although the petrographic analyses of Central German axeheads, blanks, and raw materials is an ongoing project whose first results will soon be made public, the present study aims to offer a preliminary systematic presentation of all the manufacture evidence studied in the archive of the State Museum of Prehistory in Halle (Saale) and the State Office for Archaeology Saxony, as well as all the information published dispersedly over the last 150 years (since Schultheiß 1875).

1 E.g., Bradley/Edmonds 1993; Pétrequin et al. 2012; Pétrequin et al. 2017; Risch 2011; Delgado-Raack et al. 2020.
2 Kaufmann 2020; Schwarz-Mackensen/Schneider 1983; Schwarz-Mackensen/Schneider 1983a; Schwarz-Mackensen/Schneider 1986.
3 Šída 2009; Ramminger/Šída 2012; Ramminger 2007; Šrein et al. 2002; Šrein et al. 2003; Prostředník et al. 2005; Monik et al. 2021.
4 Esp. Pietzsch 1951; Quitta 1955; Baumann 1962; Vencl 1975.
5 Pétrequin/Jeunesse 1995, 61; 64; 66; Delage 2004, 36; Bradley/Edmonds 1993, 144–150; Risch/Martínez 2008.
6 Lehmann 1927; Wagener 1928; Pietzsch 1951; Herrmann/Schüller 1952; Quitta 1955; Küßner/Neumann 2008; Martin 2020; etc.
7 Stautz 1910; Kade 1931; Herrmann/Schüller 1952; Quitta 1955; Scholz 1986; Hesse 1969.

Materials and methods

The study of over 3000 polished artefacts from the collection of the State Museum of Prehistory in Halle (Saale), along with 1100 additional artefacts from the State Office for Archaeology Saxony, has allowed us to identify a total of 357 axe blanks and remnants of axe production processes. They come from over one hundred localities in Saxony-Anhalt and Saxony as well as from the border areas in neighbouring Thuringia, Saxony, and Brandenburg.

While the majority of these axe blanks are part of old surface find collections, a total of 119 artefacts, including blanks as well as finished axeheads and drillcores, can be assigned to sites where excavations have been performed by the State Office of Heritage Management and Archaeology Saxony-Anhalt and the State Office of Archaeology Saxony. In most contexts, pottery is used to assign a site to a certain culture and thus to a certain chronology. Moreover, the typology of the axe blanks can be used as a rough chronological classification. For example, axe blanks in the shape of shoe-last celts can be dated to the Early Neolithic, whereas the pecked battle axes can be classified as Late Neolithic (2700–2200 BC)[8]. The sites of Breitenbach (Wetterzeube), Burgenlandkreis district (Zamzow 2020; Siegl/Wunderlich 2013), Eilsleben[9], Börde district, Niederröblingen, Mansfeld-Südharz district (Wollenweber 2020), Birmenitz[10], Meißen district, Zwenkau-Harth, Leipzig district (Quitta 1955; Quitta 1958; Stäuble 2010) and Zauschwitz, Leipzig district (Stäuble 2010; Bergemann 2018) can be dated to the Early Neolithic; the sites at Halberstadt-Spiegelsberge, Harz district (Toepfer 1957) and Westerhausen-Jächtenberg, Harz district (Rinne/Schmidt 2006) can be assigned to Middle Neolithic cultures. Furthermore, one axe blank found in the Únětice settlement of Schiepzig, Saalekreis district, can be dated to the Early Bronze Age (Moser 2019).

All 357 axe blanks, drillcores, and production remnants have been inventoried according to analytical criteria adapted from the method of macrolithic analysis proposed by R. Risch (2002) and refined in successive research (Delgado-Raack 2008; Ache 2019; Vuckoviç 2019; etc.). In addition to metrical and morpho-technical variables and production traces (sawing, flaking, and pecking marks), a first classification of the raw material of the artefacts was obtained by observation under a stereoscopic loupe (30/40 x). A sample of items from each of the identified material groups was selected and prepared for thin-section analysis. This allowed us to determine the mineral composition of 40 axeheads and 7 blanks by using a Nikon Eclipse E400 Pol Microscope. Accessories and opaque mineral phases could be identified via Scanning-Electron-Microscopy (EDS; using a Zeiss Merlin FE-SEM with 20 kV voltage and 1nA current). This two-step procedure allowed us to confirm and refine the initial petrographic classification.

In order to supplement the spatial distribution pattern of the axe blanks, specimens from hoard finds (for a reference list, see Tab. 3) and published blanks[11] were also included in our database. Although there are many finds of finished and well-polished tools with remnants of sawing marks, only blanks are considered in this study.

Results

Morpho-technical observations

Manufacturing remains

The 357 axe blanks, axeheads with unfinished perforation, and manufacturing debris can be organised into different morpho-technical groups depending on the overall shape and the manufacturing traces (see Tab. 1; Pl.). Since the production of axeheads is a process with several overlapping steps, most blanks show a combination of different production traces. While sawing marks and flake extraction negatives are related to the initial working stages, axes with unfinished perforations and drilling cores provide information about later stages in the manufacturing or recycling of axes. The manufacturing evidence found in Central Germany can be grouped into a series of morpho-technical categories (see Pl.).

Slabs and axe blanks with sawing marks (S)

Natural slabs and axe blanks can feature a straight or concave sawing mark on at least one of the artefacts' sides. Axe blanks are further shaped by flaking or pecking, but remnants of the natural, weathered rock surface remain visible.

S_Sl_S1_VU describes a rock slab **(Sl)** with a natural, unprocessed surface featuring one unfinished sawing cut with a V- or U-shaped (**VU**) cross section on the slab's ventral surface (Pl. 1,2). The shape of the cross-section is dependent on the depth of the cut, starting with a wide U-shape and becoming more V-shaped with the increasing depth of the cut.

S_Sl_S1_VU_Fr are fragments (**Fr**) of **S_Sl_S1_VU** or **S_Sl_S1** with an unfinished cut.

S_Sl_S1 describes rock slabs (**Sl**) with an unprocessed, natural surface and one straight sawing mark (**S1**) along the long side (cf. Pl. 1,1). So far, no slabs with more than one sawn side have been observed.

S_Bl_S1 describes fully preserved blanks (**Bl**) with one straight sawing mark on the longest side (cf. Pl. 1,3). The dorsal and ventral sides of the blank often feature remnants of the original, weathered rock surface while the top and bottom faces, as well as the side opposite of the saw mark, often show signs of flaking (cf. Pl. 1,3).

S_Bl_S1_Fr are fragments of sawn axe blanks, featuring traces of sawing on one side and at least one broken side. It is unclear whether these fragments are remnants of axe blanks or rather leftovers from the production process.

8 Brandt 1967; Struve 1955; Kaufmann 2020; Behrens 1973.

9 Kaufmann 1981; Kaufmann 1982; Kaufmann 1983; Kaufmann 2010.

10 Hottenroth 1903; Herrmann/Schüller 1952; Fröhner/Strobel 2016; Strobel/Westphalen 2017.

11 Pietzsch 1951; Kaufmann 1959a; Höckner 1962; Vencl 1975; Küßner 2006; Jansen 2013; Petzold 2013; Kaufmann 2020; Martin 2020.

S_Bl_S2 describes fully preserved blanks with two straight saw marks, usually on both longer, lateral sides (Pl. 2; Pl. 3,1). The dorsal and ventral sides of the blank often feature remnants of the original, weathered rock surface, while the shorter end-sides frequently show signs of flaking.

S_Bl_S2_Fr are fragments of **S_Bl_S2**.

S_Bl_S3 are blanks and unfinished axeheads with sawing marks on three sides. So far, only one artefact belongs to this category. Polishing covers almost its entire surface, but does not obliterate the original sawing marks on both long sides and on the neck of the perforated axe (cf. Pl. 3,2).

S_Bl_S3_Fr would be fragments of **S_Bl_S3** but have not been observed so far.

S_Bl_SC describes an axe blank with the shape of a shoe-last celt. This variety presents one strongly curved sawing mark along the long side of the shoe-last celt (Pl. 4,1). Shoe-last celts (also known as high adzes) are a common adze type in the Early Neolithic in Central Germany and are defined by their D-shaped cross-section and a height-to-width ratio of > 1[12].

Flaked axe blanks (F)

Axe blanks shaped exclusively by knapping (**F**). Remains of the natural rock surface can be observed in some blanks.

F_Bl are fully preserved flaked axe blanks. The surface is covered in negative flake scars, and small remains of the weathered natural rock surface on the ventral and dorsal sides of the blank are often visible (cf. Pl. 4,2; Pl. 5,1).

F_Bl_Fr are fragments of flaked axe blanks.

Axeheads (AH) with one or two unfinished perforations (UP)

This category is used for axes and adzes with traces of drilling. In most cases, the perforation is done by hollow drilling, and remnants of a drillcore are visible. These axes and adzes are fully shaped, and they can often be classified according to the conventional axehead typologies (Struve 1955; Brandt 1967). Their surfaces are pecked and/or polished. The unfinished perforations can often be observed on two opposite sides of the axehead and were supposed to meet in the middle to create the shaft hole.

BA_UP are tools in the shape of a battle axe (**BA**) (as defined by Struve 1955) with an entirely pecked surface yet without perforation (cf. Pl. 5,4; Pl. 6,1). Some artefacts show a pecked mark where the drill is going to be placed (cf. Pl. 6,1).

AH_UP are pecked and polished tools with an unfinished perforation (cf. Pl. 6,2–3). The perforation can be either done by full drilling or hollow drilling, whereby hollow drilling produces a conical core in the drill hole. Alternating unfinished perforations on both sides of the axeheads are very common in this category.

AH_UP_Fr are fragments of pecked and partly polished tools featuring an unfinished perforation.

SC_UP describes polished shoe-last celts with an unfinished hollow perforation and initial traces of a conical core (cf. Pl. 6,4). Alternating unfinished perforations have not been observed for the shoe-last celts. Fragments of **SC_UP** have not been observed so far. Due to the complicated and often uncertain classification of fragments, **SC_UP** fragments have likely been identified as the more unspecific category of AH_UP_Fr.

Drillcores (DC)

Drillcores are the result of completed hollow perforations of axes and are frequently found in Neolithic settlements. As the traces of unfinished perforation, they do not necessarily relate to the initial manufacture of the axeheads but could be the result of later reshaping or, rather, rehafting processes of axeheads.

DC are drillcores (cf. Pl. 5,1–2).

DC_Fr describes fragments of drillcores. Here, the base of the core usually shows signs of breakage.

Manufacturing process

So far, no unprocessed raw materials have been found in Neolithic settlements and deposits. The largest known slabs of actinolite-hornblende-schist (henceforth AHS) with sawing marks are up to almost 400 mm in length and 100 mm in width, and can weigh over 2 kg. The height of these slabs (S_Sl_S1) ranges between 24–48 mm and provides a direct insight into the structure of the exploited metabasite outcrop. The natural rock surface can also be seen on many other flaked and sawn blanks and allows us to calculate an average slab thickness of 32.5 mm (σ = 11.8), although some slabs can even reach a thickness of over 60 mm (cf. Fig. 1).

One of the largest processed slabs comes from the deposit of Zwenkau-Harth (Quitta 1955). It has a more or less square shape and was sawn through on two sides perpendicular to each other. The other two sides had been prepared through flaking. All studied slabs of type S_Sl_S1 feature only one prominent straight saw surface or groove on the longest side (cf. Fig. 3; cf. Pl. 1,1). On some specimens, remnants of a pre-pecked line can be identified, which probably aided the placement and stabilisation of the sawing blade at the beginning of the process (Pietzsch 1951; Ganslmeier 2021). The intention behind the sawing was to create a weak line along which the rock piece could be split in half by applying pressure. The depth of the sawing mark reaches, on average, half of the slabs' thickness.

The size and shape of the natural rock slabs show a specific selection of suited material, since the slab thickness determines the height or width of the axehead. The lengthwise sawing of the rock slab allowed the manufacturers to make maximal use of the available raw material by cutting as many blanks as possible from one slab (Quitta 1955).

The relatively low number of slabs in contrast to the relatively abundant blank fragments found in the Neolithic settlements and deposits of Central Germany (Tab. 1) suggests that slabs were prepared and sawn at or near the quarry sites before being transported to the workshops. Here the slabs were either cut or directly flaked into blanks, depend-

12 Brandt 1967; Struve 1955; Weller 2014; Schauer 2018.

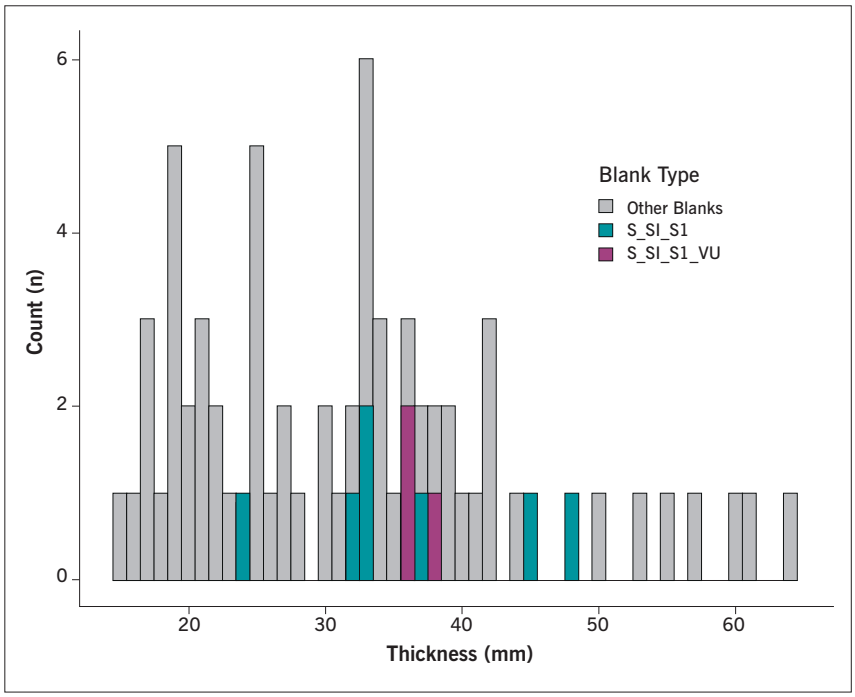


Fig. 1 Thickness of AHS rock slabs measured on natural rock slabs with sawing marks (types S_Sl_S1 and S_Sl_S1_VU) and on flaked and sawn blanks with visible remnants of the natural rock surface.

Abb. 1 *Dicke von Steinplatten aus Aktinolith-Hornblende-Schiefer, gemessen an natürlich vorkommenden Steinplatten mit Sägespuren (Typen S_Sl_S1 und S_Sl_S1_VU) und an geschlagenen und gesägten Rohlingen mit sichtbaren Resten der natürlichen Oberfläche des Steins.*

Axe manufacture evidence	Subgroup	Number (n)	Natural rock surface	Sawing marks	Flake extraction	Pecking marks	Polished surface
Axe blanks with sawing marks	S_Sl_S1_VU, S_Sl_S1_VU_Fr	9	x	x	(x)		
	S_Sl_S1	8	x	x	x		
	S_Bl_S1	11	x	x	x		x
	S_Bl_S1_Fr	70	x	x	x		x
	S_Bl_S2	4	x	x	x		x
	S_Bl_S2_Fr	23	x	x	x		x
	S_Bl_S3	1	x	x			x
	S_Bl_SC	2	x	x	(x)	x	x
	Subtotal	**129**					
Flaked axe blanks	F_Bl,	97	x		x		x
	F_Bl_Fr						
Production debris	DC,	101	x				x
	DC_Fr						
Axeheads with unfinished perforation	BA_UP	5				x	
	AH_UP, AH_UP_Fr	20				x	x
	SC_UP	5	(x)		x	x	x
	Subtotal	**30**					
TOTAL		**357**					

Tab. 1 The studied axe blanks and production remains have been grouped depending on their overall shape and manufacturing traces. Most blanks show a combination of different production traces. x = traces visible in over 75 % of studied artefacts; (x) = traces visible on single artefacts.

Tab. 1 *Die untersuchten Beil- und Axtrohlinge sowie Produktionsreste wurde nach ihrer Gesamtform und den Herstellungsspuren gruppiert. Die meisten Rohlinge weisen eine Kombination unterschiedlicher Produktionsspuren auf. x = Spuren auf über 75 % der untersuchten Artefakte sichtbar; (x) = Spuren auf einzelnen Artefakten sichtbar.*

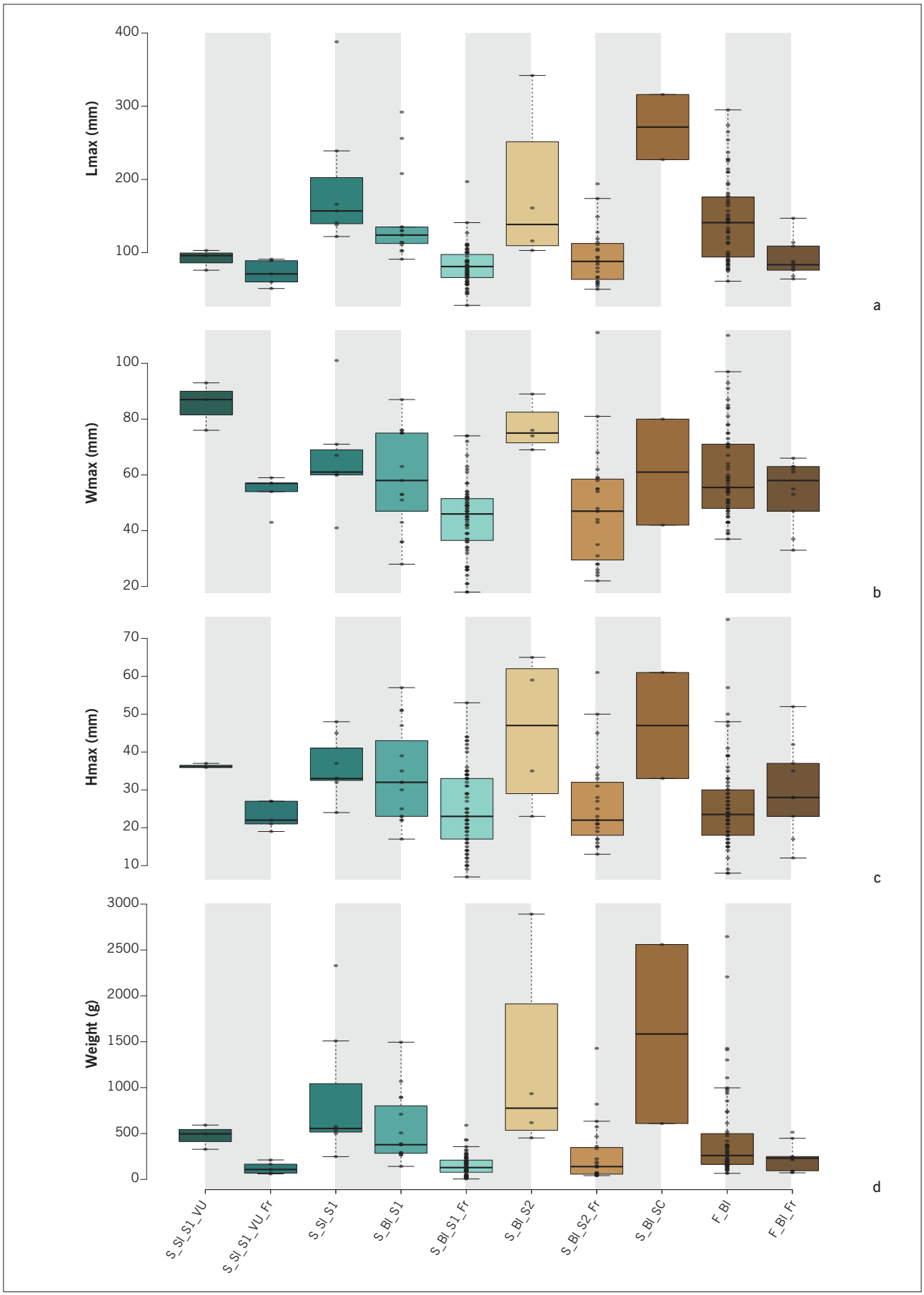


Fig. 2a–d Comparison of length (a), width (b), height (c), and weight (d) between sawn and flaked axe blanks made from AHS and metabasites.

Abb. 2a–d *Vergleich von Länge (a), Breite (b), Höhe (c) und Gewicht (d) zwischen gesägten und durch Abschläge geformten Rohlingen aus Aktinolith-Hornblende-Schiefer und Metabasiten.*

Fig. 3a–c a 92:280e – shoe-last celt-shaped axe blank with curved sawing marks; besides the sawing mark, flaking and pecking traces are also visible on the blank; b 71:810 – natural rock slab with straight sawing marks along the longest side; c 41:1670 – axe blank with straight sawing mark along the longest side and traces of flaking on the surface.

Abb. 3a–c *a 92:280e – schuhleistenkeilförmiger Rohling mit gebogenen Sägespuren; daneben sind auch Spuren vom Abschlagen und Picken sichtbar; b 71:810 – natürliche Steinplatte mit geraden Sägespuren entlang der längsten Seite; c 41:1670 – Rohling mit geraden Sägespuren entlang der längsten Seite und Spuren vom Abschlagen auf der natürlichen Oberfläche.*

ing on the size of the original slab. The hoard of Vollersroda, Weimarer Land district, provides an example where two blanks in the shape of shoe-last celts were sawn from the same slab (Küßner/Neumann 2008).

Sawing in the settlements is also indicated by a small number of slabs and rock fragments with an unfinished incision on the ventral surface (S_Sl_S1_VU and S_Sl_S1_VU_Fr). Again, the raw material is exclusively actinolite-hornblende-schist (AHS) and related metabasites. The sawing groove of the slabs maintains a U-shaped cross-section up to a depth of 8–10 mm, after which the groove gradually becomes V-shaped.

The studied slabs of type S_Sl_S1_VU and S_Sl_S1_VU_Fr do not show traces of a pre-pecked line, suggesting a slightly different technical procedure than the processing of large slabs. The few complete remains of these partially sawn slabs show traces of weathered surfaces, implying that occasionally cobble stones from fluvial deposits were selected. Furthermore, another difference with the quarried slabs is their larger width and smaller length and weight, whereas their thickness is similar (Tab. 2; cf. Fig. 1; Fig 2). The collection and processing of relatively small AHS clasts from fluvial deposits is another indication that the AHS source or sources are located relatively close to the Neolithic settlements.

Sawing marks are also visible along the longest side of a large number of blanks (S_Bl_S1) and blank fragments (S_Bl_S1_Fr). The axe blanks in the shape of shoe-last celts, which are typical of the Linear Pottery, Stroke Ornamented Pottery, and Rössen Cultures, were clearly manufactured by sawing at least one of the sides (S_Bl_SC). Some blanks present sawing marks on two or three sides (S_Bl_S2 and 3). These traces can be classified into two groups according to their orientation: 1) slightly curved or 2) straight traces. While the majority (~ 90 %) of the sawn pieces show rather straight sawing marks with parallel grooves, the shoe-last celts as well as some bigger axe blanks (one- and two-sided sawn blanks) and single fragments feature slight to markedly curved striations (Fig. 3a).

The sawing of rocks in Later Prehistory has sparked the interest of researchers since the late 19th century (Keller 1870), and a plethora of sawing devices have been discussed over the last 150 years, focusing on the saw blade used as

General Information					Measurements						
Site	Locality	Overall dating of site	Type	Amount (n)	Wgt_{max} $\bar{x}$ (g)	σ (g)	L_{max} $\bar{x}$ (mm)	σ (mm)	W_{max} $\bar{x}$ (mm)	σ (mm)	H_{max} $\bar{x}$ (mm)
EN sites: Breitenbach, Eilsleben, Niederröblingen, Birmenitz, Harth, Zauschwitz	Saxony-Anhalt and Saxony, Germany	LBK, SBK, Rössen	S_SI_S1_VU	1	592		103		93		36
			S_SI_S1_VU_Fr	5	128	63	77	23	55	6	21
			S_BI_S1	6	472	243	116	17	61	17	35
			S_BI_S1_Fr	34	130	114	76	28	43	13	23
			S_BI_S2_Fr	14	293	347	99	37	51	25	26
			F_BI	13	289	173	126	42	58	10	23
			F_BI_Fr	1	53		45		43		15
			AH_UP_Fr	1	41		30		23		29
			DC	13	14	8	23	7	18	3	
			DC_Fr	2	4	2	12	7	15	1	
			Total N	**90**							
MN sites: Halberstadt-Spiegelsberge, Westerhausen B 6n	Saxony-Anhalt, Germany	Bernburger Culture, Schönfelder Culture, Salzmünde Culture	S_BI_S1_Fr	3	86	50	77	16	40	4	25
			S_BI_S2_Fr	1	820		103		81		61
			F_BI	18	228	486	96	40	44	10	23
			F_BI_Fr	4	260	157	86	17	53	11	36
			BA_UP	1	238		92		40		38
			AH_UP_Fr	1	367		118		65		32
			Total N	28							
BA sites: Schiepzig	Saxony-Anhalt, Germany	EBA, Aunjetitz Culture	F_BI_Fr	1	232		78		63		28
			Total N	**1**							
Single finds	Saxony-Anhalt, Germany	undated	S_SI_S1_VU	2	412	84	86	10	82	6	37
			S_SI_S1_VU_Fr	1	166		89		54		27
			S_SI_S1	8	924	653	201	84	69	18	36
			S_BI_S1	5	718	494	195	75	56	18	34
			S_BI_S1_Fr	34	174	109	85	21	45	13	27
			S_BI_S2	4	1224	978	181	96	77	7	46
			S_BI_S2_Fr	8	127	179	85	36	45	10	23
			S_BI_S3	1	982		233		70		37
			S_BI_SC	2	1585	976	272	45	61	19	47
			F_BI	55	452	471	145	58	61	17	27
			F_BI_Fr	5	219	135	98	29	53	11	26
			BA_UP	4	557	102	117	2	49	7	49
			AH_UP	13	523	629	127	54	47	15	38
			AH_UP_Fr	5	243	138	75	22	51	6	35
			SC_UP	5	476	318	174	50	29	7	42
			DC	70	20	9	32	9	19	3	
			DC_Fr	16	7	3	13	4	18	3	
			Total N	**238**							

Tab. 2 Overview of metric data and lithic raw materials of the studied axe blanks, manufacturing debris, and axeheads with unfinished perforation. Explanation of abbreviations: LBK = Linear Pottery Culture; SBK = Stroke Ornamented Pottery Culture; EBA = Early Bronze Age; Wgt = weight; L = length; W = width; H = hight; max = maximum; $\bar{x}$ = average; σ = standard deviation; S1 = 1st saw mark; S2 = 2nd saw mark; S3 = 3rd saw mark; CURV_S = curvature of saw mark; RT = straight; CV = concave; Ø $\bar{x}$ = average diameter; AHS = actinolite-hornblende-schist; MBAS = metabasites; WDS = Wiedaer Schiefer; MSED = metasediments; Mafic = mafic to intermediate rocks; Felsic = felsic to intermediate rocks.

													Lithic Raw Material (n)					
σ (mm)	L_{max} x̄ S1 (mm)	σ (mm)	L_{max} x̄ S2 (mm)	σ (mm)	L_{max} x̄ S3 (mm)	Depth x̄ S1 (mm)	σ (mm)	Depth x̄ S2 (mm)	σ (mm)	Depth x̄ S3 (mm)	CURV_S	Drill Hole Ø x̄ (mm)	AHS	MBAS	WDS	MSED	Mafic	Felsic
	52		56			2		10			RT, U		1					
4	61	22	61	3		10	4	2			RT, U, V		4	1				
9	91	25				17	5				RT		6					
11	64	26				14	5				RT, CV (3)		29	4			1	
11	85	31	70	30		14	4	10	7		RT, CV (3)		12	2				
8													11	2				
														1				
													1					
													13					
													2					
9	42	24				6	2				RT				3			
	82		67			39		36			RT	25		1				
14													1	1	16			
11														1	3			
																		1
												19		1				
													1					
1	74	11				12	2				RT, V		2					
	61		39			18		15			RT, V		1					
7	195	89				20	8				RT		7			1		
16	123	49				15	8				RT, CV (2)		5					
11	78	21				16	6				RT, CV(2)		30	2		1	1	
17	148	107	122	107		21	8	20	8		RT, CV (1)	18	4					
6	75	32	62	27		14	5	12	6		RT, CV (1)		8					
	225		188		68	21		20		15	RT-CV	17	1					
14	173	7				25	4				CV		2					
10													42	4	4	4	1	
10													4			1		
1														2			2	
14												17	2	5		1	3	2
9												19	3	1				1
14												17	5					
													61	2		5	2	
													13				2	1

Tab. 2 Übersicht der metrischen Daten und des lithischen Rohmaterials der untersuchten Rohlinge, der Herstellungsreste und der Axtklingen mit unvollständiger Lochung. Verwendete Abkürzungen: LBK = Linearbandkeramische Kultur; SBK = Kultur der Stichbandkeramik; EBA = Frühe Bronzezeit; Wgt = Gewicht; L = Länge; W = Breite; H = Höhe; max = Maximum; x̄ = Durchschnitt; σ = Standardabweichung; S1 = erste Sägespur; S2 = zweite Sägespur; S3 = dritte Sägespur; CURV_S = Krümmung der Sägespur; RT = gerade; CV = konkav; Ø x̄ = mittlerer Durchmesser; AHS = Aktinolith-Hornblende-Schiefer; MBAS = Metabasite; WDS = Wiedaer Schiefer; MSED = Metasedimente; Mafic = mafische bis intermediäre Gesteine; Felsic = felsische bis intermediäre Gesteine.

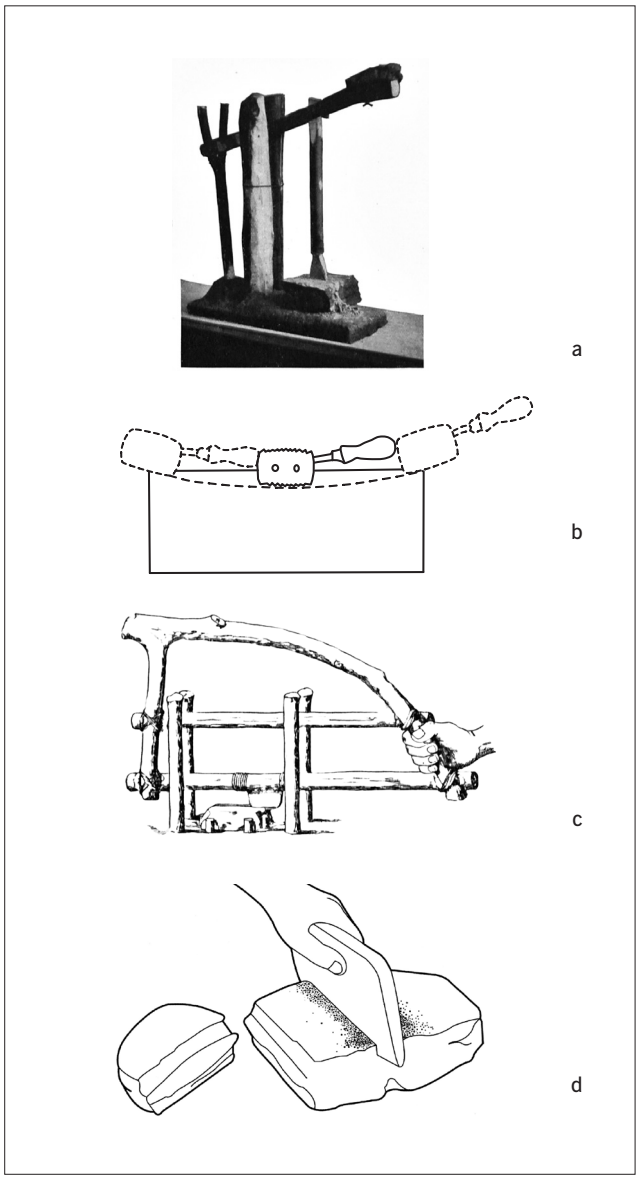


Fig. 4a–d a Pendulum stone saw as depicted by La Baume (1934, 73) explaining the strongly curved saw marks; b another explanation for the curved incision is provided by Pietzsch (1951, 32) and features a stair saw or a handheld blade where more pressure is applied in the centre of the artefact during the sawing process, causing a concave incision; c stone sawing device depicted by Pietzsch (1951, 33); a wooden sawing blade is moved back and forth with a handheld device, abrasing the rock material with a mix of sharp quartz sand and water, leading to a straight sawing mark as seen in many of the sawn artefacts; d a simple hand-held saw, as proposed by the Archaeological Museum of Chemnitz (Saxony), probably also leading to straight sawing marks (Wolfram et al. 2014, 98).

Abb. 4a–d *a Pendelsteinsäge nach La Baume (1934, 73), welche die stark gekrümmten Sägespuren erklären würde; b eine weitere Erklärung für den gebogenen Schnitt liefert Pietzsch (1951, 32) mit einer Gratsäge oder einem handgeführten Sägeblatt, wo in der Mitte des Artefakts beim Sägen mehr Druck ausgeübt wird, was zu einem konkaven Schnitt führt; c bei Pietzsch (1951, 33) dargestellte Vorrichtung zum Steinsägen, bei der ein hölzernes Sägeblatt mithilfe einer handgehaltenen Vorrichtung vor- und zurückbewegt wird, sodass das Gesteinsmaterial mittels einer Mischung aus scharfem Quarzsand und Wasser abgeschürft wird, was zu einem geraden Sägeschnitt führt, wie man ihn an vielen gesägten Artefakten sieht; d eine einfache Handsäge, wie sie das Staatliche Museum für Archäologie Chemnitz (Sachsen) vorschlägt, führte vermutlich ebenfalls zu geraden Sägespuren (Wolfram et al. 2014, 98).*

well as the sawing techniques themselves[13]. Curved sawing marks have been interpreted as the result of a pendulum saw (Fig. 4a; La Baume 1934; La Baume 1943) or of a stair saw (cf. Fig. 4b; Pietzsch 1951). By contrast, the more frequent straight sawing marks have been explained by the use of a sawing device as depicted by Pietzsch in 1951 (cf. Fig. 4c), or a handheld saw blade (Weiner 1996; cf. Fig. 4d). The saw blade itself has also been part of the discussion since sawing in the Neolithic was rather a linear abrasion than what we know as sawing in later periods (Weiner 1996). While saw blades made of sandstone or quartzitic rocks have occasionally been found (Wessel 1996; Stolz 2016; Kaufmann 2020, 84–85), the dominant view is that wood devices were used in combination with sharp quartz sand and water to perform the abrasion task.

Due to the low number of dated artefacts, it is unclear whether the different sawing techniques correlate with different periods or cultures. However, since curved or straight (cf. Fig. 3; cf. Fig. 9) sawing marks can be found on the same axe type (shoe-last celts), both sawing techniques were definitely used during the Early Neolithic.

After sawing, the rock slabs were further shaped by flaking or pecking. The removal of excess rock material resulted in slightly smaller and lighter blanks (cf. Tab. 2; cf. Fig. 2). Both processes were carried out with hammerstones, which are abundant in any macrolithic record of Neolithic settlements of Central Germany.

The hafting of axeheads through circular perforations is known in Central Europe since the early Linear Pottery and Stroke Ornamented Pottery Culture (Rieth 1958) and can be observed on many types of Neolithic axes. Perforations were drilled vertically through the axes with a round and hollow cylinder, probably made out of elder wood or bone diaphysis, and the use of fine quartz sand and water (Rieth 1958; Ganslmeier 2021). A secondary product of this manufacturing process, which can take place at any stage in the use-life of an axehead, are cone-shaped drillcores. They have a cone-shaped body with an average inclination of 85.3° (σ = 1.7°). While the minimum diameter can be as thin as 8 mm, the widest part can reach up to 25 mm in diameter. The average diameter of these drillcores lies between 18–19 mm, which matches the unfinished drillholes in perforated axes with an average diameter of 18.5 mm (cf. Tab. 2).

Raw Materials

Petrographic studies

The petrographic terminology used to describe the Neolithic axes in Central Europe is far from unified. The terms »amphibolite«[14], »hornblende-schist« (Luedecke 1902; Behrens 1983), or »green rocks« (Herrmann/Schüller 1952; Quitta 1955) have regularly been used to describe the dominant raw material of Neolithic axes. They commonly show a greenish to greyish colour and often a slight deformation

13 Keller 1870; Schultheiß 1872; Pfeiffer 1912; La Baume 1934; La Baume 1943; Ischer 1941; Pietzsch 1951; Herrmann/Schüller 1952; Schrickel 1952; Willms 1980; Weiner 1996; Lessig 2003.

14 Rieth 1958; Arps 1978; Behrens 1983; Scholz 1986.

and can be labelled as metabasites, a group of metamorphic rocks with a basic protolith origin covering all varieties of greenschist, greenfels, dolerite, (meta)cinerite, and amphibolite as well as the so-called actinolite-hornblende-schist (AHS).

Apart from AHS, macroscopic observation of the 3000 artefacts and petrographic studies of a total of 47 artefacts has allowed us to identify five additional rock categories: metabasites (other than AHS), mafic rocks, felsic rocks, metasediments, and Wiedaer Schiefer (WDS). These identifications have been confirmed through thin sections and SEM of axe blanks made of AHS and of finished artefacts made of all rocks.

Actinolite-hornblende-schist (AHS)

The term actinolite-hornblende-schist was established by G. Schwarz-Mackensen and W. Schneider (1983; Schwarz-Mackensen/Schneider 1986). This rock is the most common material used for Early Neolithic axes throughout Central Europe (Nowak 2008; Moník et al. 2021). It is part of the metabasite rock group and has also been referred to as »Jizera-type metabasite« (Šída/Kachlik 2009) with a known provenance in the Jizera Mountains near Jistebsko, where it was quarried extensively during the Early Neolithic[15].

Thin-section studies of the AHS samples revealed petrographic correspondence with the Jizera metabasites as described by P. Šída and V. Kachlik (2009). The rock shows a very fine-grained and highly deformed texture with elongated sigmoidal-shaped aggregates consisting of plagioclase and minor quartz surrounded by at least two generations of amphibole (see Fig. 5a–g,j). The amphibole shows a pale green to almost transparent colour and occurs in fibrous, decussate, almost felt-like mats of amphibole intergrown with single bigger amphibole needles. Opaque mineral phases and fibrous amphibole define the foliation, which can be more or less prominent depending on the sample (cf. Fig. 5a–g,j). The opaque mineral phases were identified, using SEM-EDS, as Mn-bearing ilmenite (Fig. 5m–n). The amount of ilmenite in the studied AHS samples can range between 5–15 %, while actinolite and hornblende account for up to 70 %. The content of plagioclase ranges between 15–25 % and shows an intermediate to Ca-rich composition (anorthite). Chlorite is often present as an accessory mineral, as well as apatite, epidote, and titanite, which rims the ilmenite crystals. SEM analysis also revealed orthoclase and pyrite as accessory minerals in some samples. The amphiboles could be further identified via SEM-EDS as clinoamphiboles, including the Ca-amphiboles actinolite and Mg-hornblende, and as cummingtonite. Petrographically, this rock would be classified as actinolite-hornblende-bearing foliated metabasite. However, actinolite-hornblende-schist (AHS) is the widely used definition of this rock in the geoarchaeological studies of Central Europe.

Metabasites (other than AHS)

Based on the thin sections of polished axes, metabasites other than AHS have been identified among Central German stone tools. Metabasites are a group of metamorphic rocks with a basic protolith origin. In the artefacts studied, amphibolites, (meta)dolerites, greenschists, and metacinerites could be identified. Some axe blanks could not be defined macroscopically as AHS and probably belong to these types of metabasite rocks. Amphibolites are rocks formed by the amphibolite facies metamorphism of basic protoliths. They usually contain amphibole group minerals (esp. hornblende and actinolite) and plagioclase, and show a weakly foliated structure. Garnet, biotite, epidote, quartz, and opaque mineral phases can be found as accessories. Dolerites are subvolcanic rocks with a basaltic/gabbroid mineral composition. They are often metamorphosed into greenschists featuring a foliated texture and a mineral composition typical for greenschist to amphibolite facies metamorphism – namely amphibole group minerals (esp. actinolite), plagioclase, epidote, chlorite, and quartz. Metacinerites are volcanic ashes or tuff featuring a very fine-grained isotropic-to-slightly-foliated texture. They can also be described as greenschists showing an abundance of chlorite with minor quartz and opaque mineral phases.

Mafic rocks

Mafic rocks were predominantly determined among axeheads and axeheads with unfinished perforation; in isolated cases, they were also observed macroscopically among axe blanks. The term »mafic rock« is used for a range of igneous and volcanic rocks with a mafic to intermediate mineral composition that includes diorite and basalt as well as gabbro.

Basalt is a volcanic rock featuring a general mineral composition of calcic plagioclase, pyroxene, and olivine with minor foids and interstitial quartz and a rather fine-grained texture. It is the volcanic equivalent to gabbro, which is a plutonic rock with an equigranular texture and a general mineral composition of calcic plagioclase, pyroxene, and iron oxides, and it often contains olivine. Diorite is also a plutonic rock with a coarse-to-medium-grained texture and a mineral composition of intermediate plagioclase and hornblende. Biotite and Augite are also often present.

It is of interest that, so far, no alkali olivine basalt has been identified among the axeheads, nor among the blanks of Central Germany. This basalt is the second most important raw material in the northern Hesse region, where it represents 29.5 % of all Early Neolithic axeheads and 92 % of the 36 recognised adze blanks (Kegler-Graiewski 2007, 143; 179). Although no quarry evidence has been found so far, most probably it was obtained from one of the many volcanic outcrops existing in the northern Hesse depression. In contrast to AHS, which accounted for 67.4 % of the adzes of northern Hesse despite its distant origin, the distribution of olivine basalt seems to have been much more limited.

15 Šída 2009; Ramminger/Šída 2012; Ramminger 2007; Šrein et al. 2002; Šrein et al. 2003; Prostředník et al. 2005.

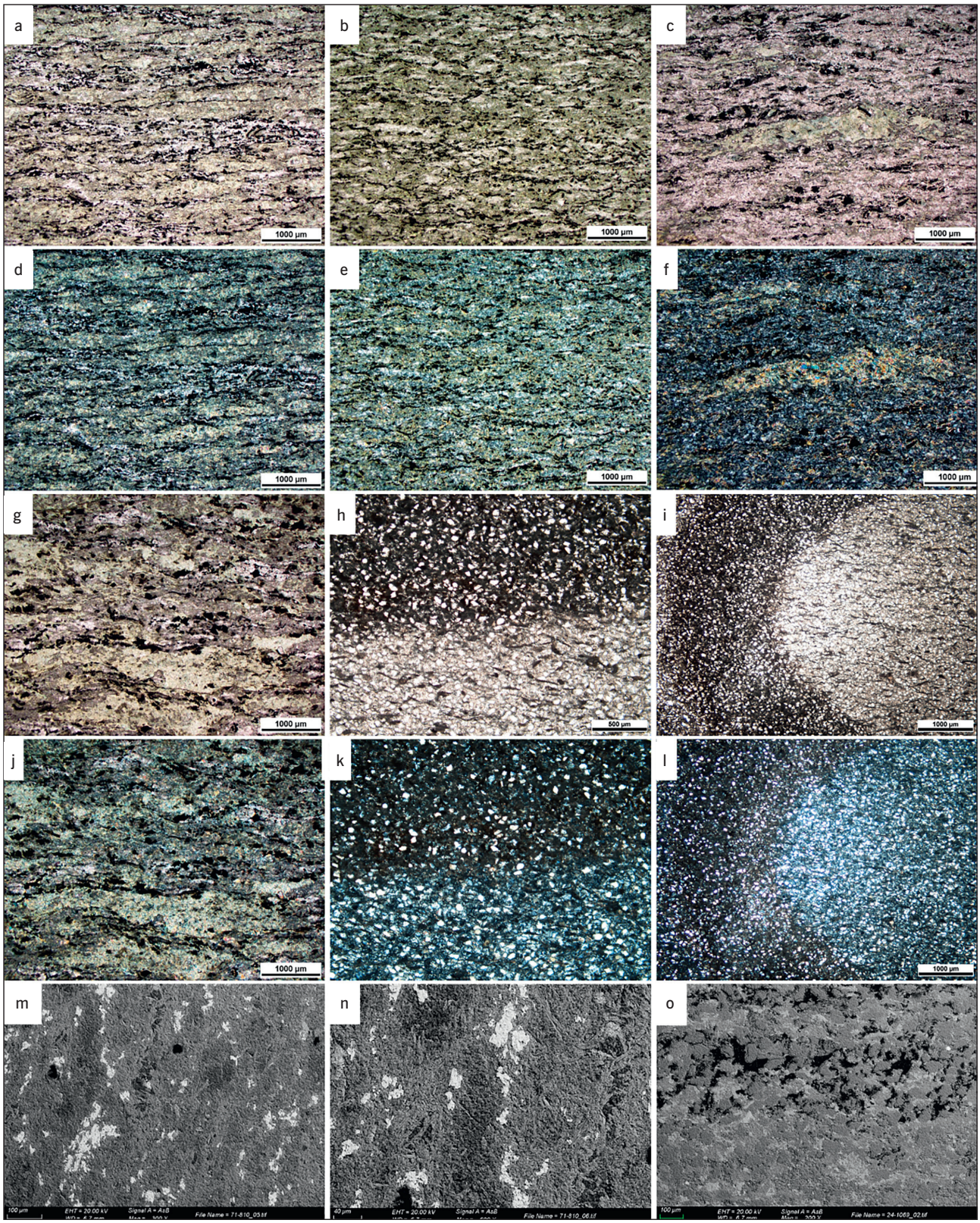


Fig. 5a–o Thin-section photos of axe blanks made of actinolite-hornblende-schist (a–g, j) and axes made of Wiedaer Schiefer (h–i, k–l) in PPL and XPL; SEM pictures of AHS (m, n) and WDS (o). Actinolite-hornblende-schist consists of pale green to transparent amphibole needles in decussate, fibrous mats, feldspar, ore minerals, and minor quartz. Ore minerals could be identified as Mn-bearing ilmenite (white) using SEM (m, n). The overall texture is fine-grained and highly deformed. Wiedaer Schiefer axes show a pale core and dark brown rim (h-I, k-l) consisting of fine quartz grains in a plagioclase-chlorite-quartz-carbonate matrix. The rim area is defined by a higher porosity (o).

Abb. 5a–o *Dünnschliffaufnahmen von Rohlingen aus Aktinolith-Hornblende-Schiefer (AHS) (a–g, j) und Beilen aus Wiedaer Schiefer (WDS) (h–i, k–l) im Polarisationsmikroskop mit linear und gekreuzt polarisiertem Licht; Rasterelektronenmikroskopaufnahmen (REM) von AHS (m, n) und WDS (o). AHS besteht aus blassgrünen bis transparenten Amphibol-Nadeln in granulitischen, faserigen Matten, Feldspat, Erzmineralien und etwas Quarz. Die Erzmineralien konnten mithilfe von REM als manganhaltiger Ilmenit (weiß) identifiziert werden (m, n). Die Textur ist insgesamt feinkörnig und stark verformt. Exemplare aus WDS besitzen einen hellen Kern und einen dunkelbraunen Rand (h-i, k-l); sie bestehen aus feinen Quarzkörnern in einer Plagioklas-Chlorit-Karbonat-Matrix. Der Randbereich zeichnet sich durch seine höhere Porosität aus (o).*

Felsic rocks

Felsic rocks were only observed macroscopically among axeheads. Halle-porphyry, rhyolite, and granodiorite are combined into the group of »felsic-to-intermediate rocks«. Granite is a coarse-to-medium-grained igneous rock with an often equigranular texture. The main minerals are plagioclase (sodic), potassium feldspar, quartz, mica, and amphibole group minerals. Rhyolite is the volcanic equivalent of granite usually featuring a porphyric texture and the same mineral composition of sodic plagioclase, potassium plagioclase, quartz, (biotite) mica, and amphibole group minerals. The Halle-porphyry describes a specific type of Permian-to-carbonic rhyolite with a porphyric texture found in the area surrounding Halle (Frühauf 2006). The main minerals are plagioclase, potassium feldspar, and quartz forming single crystals in a fine-grained matrix. Biotite and opaque mineral phases are present as accessory minerals. Granodiorite is a plutonic rock, similar to granite, featuring a coarse-grained equigranular texture but with a higher content of plagioclase and a lower amount of potassium feldspar in comparison to granite. The main minerals are plagioclase, quartz, mica and amphibole group minerals.

Metasediments

Metasediments – such as greywacke, (hornfelsic) metapsammites, and quartzitic rocks – provide another important raw material source for Neolithic axe and adze production. Their fine-grained and quartz-rich mineral composition, as well as the influence of the metamorphism on minerals and texture, grant them a relatively high mechanical resistance. Metasediments such as hornfelsic metapsammite have been identified macroscopically among some axe blanks, axeheads with unfinished perforation, and production debris. They present a fine-grained, sedimentary relic texture and a mineral composition of varying ratios of quartz, feldspar, and lithic fragments identifiable in the hand specimen. Thin sections of metasediments with the same optical features have been identified among finished axeheads.

Wiedaer Schiefer (WDS)

One of the most notable metasediments used for Neolithic axes is the so-called Wiedaer Schiefer. It is easily recognisable by its white-to-cream colour and its relatively light weight. Historically described as adinole-rich rock (Toepfer 1957), microquarzite (Köppen 2006), and quarzitic hornblende schist or schistose limestone (Jürgens 2018), our thin section analyses showed a layered structure with an unaltered core area and a heavily altered and porous rim. The rock material shows an extremely fine-grained, homogenous texture with coarser, rounded quartz grains (up to 90 µm in size) embedded in a finer matrix (cf. Fig. 5h–i,k–l, o). The composition of the matrix was identified as plagioclase, chlorite, carbonate, and quartz with accessory portions of titanite, epidote, iron oxides, rutile, zircon, and amphibole. Chlorite and plagioclase are altered and oxidised, leading to the brownish colour in the thin sections. Contrary to their former identification as schistose limestone (Jürgens 2018), calcite could not be identified in the thin sections. Staining of the thin section with alizarin red revealed an accumulation of calcium carbonate in the transition zone between the rim and core area but no Ca-carbonate in the core area, which leads to the identification of dolomite as the main matrix carbonate. The rock can therefore be classified as an altered metasiltstone.

This material was used in the Middle Neolithic around the Harz Mountains, especially in the northern Harzvorland[16]. It is associated with the Funnelbeaker, Bernburger, Salzmünder, Elb-Havel, and Walternienburger Cultures[17]. In absolute chronological terms, this corresponds to the time between 3400–2650 BC. Wiedaer Schiefer represents 25 % of all documented flaked axe blanks found in the collection of the State Museum of Prehistory in Halle. Sawing marks are very rarely observed.

The use of raw materials

AHS represents around 75 % of the sawn and flaked axe blanks of Central Germany we studied. Interestingly, it was dominant in the Early Neolithic, for example among flat adzes and shoe-last celts and their blanks, whereas it seems to have been negligible in the Middle Neolithic, when Wiedaer Schiefer and different metabasites became more common (Fig. 6a). Good examples are the pecked axeheads we studied (BA_UP) – associated with the period of the battle axes (Brandt 1967; Struve 1955) and therefore with, e.g., the Central-Eastern European Corded Ware Culture or the Battle Axe Culture in Scandinavia – which show a higher variety in the use of raw materials favouring metabasites as well as mafic and felsic rocks (cf. Fig. 6b). This change in the use of lithic raw material over time was already observed in the area around Braunschweig and the northern part of the State of Hesse, located, respectively, to the north and southwest of the Harz Mountains (Schwarz-Mackensen/Schneider 1986; Kegler-Graiewski 2007, 143–144). In both areas, the importance of (meta)mafic rocks, especially diabase and basalt, increased during the Middle and Late Neolithic.

The different types of blanks show significant variations in the raw material used (cf. Fig. 6b). An abundance of AHS and other foliated metabasites can be seen especially among sawn axe blanks (95 %), while flaked blanks show a somehow higher variability of raw material. Pecked axe blanks and axeheads with unfinished perforation show the highest diversity of raw materials with a significantly increasing amount of mafic and felsic rocks. The only exceptions are the shoe-last celts with unfinished perforation, which are exclusively made from AHS.

Since sawing has been predominantly used for AHS and related metabasites (cf. Fig. 6c), it is no surprise that sawn

16 Bartels 1956; Töpfer 1957; Dirks 2000; Rinne/Schmidt 2006; Jürgens 2017; Jürgens 2018.

17 Reuß 1907; Niklasson 1925; Sprockhoff 1926; Grimm 1938; Dirks 2000.

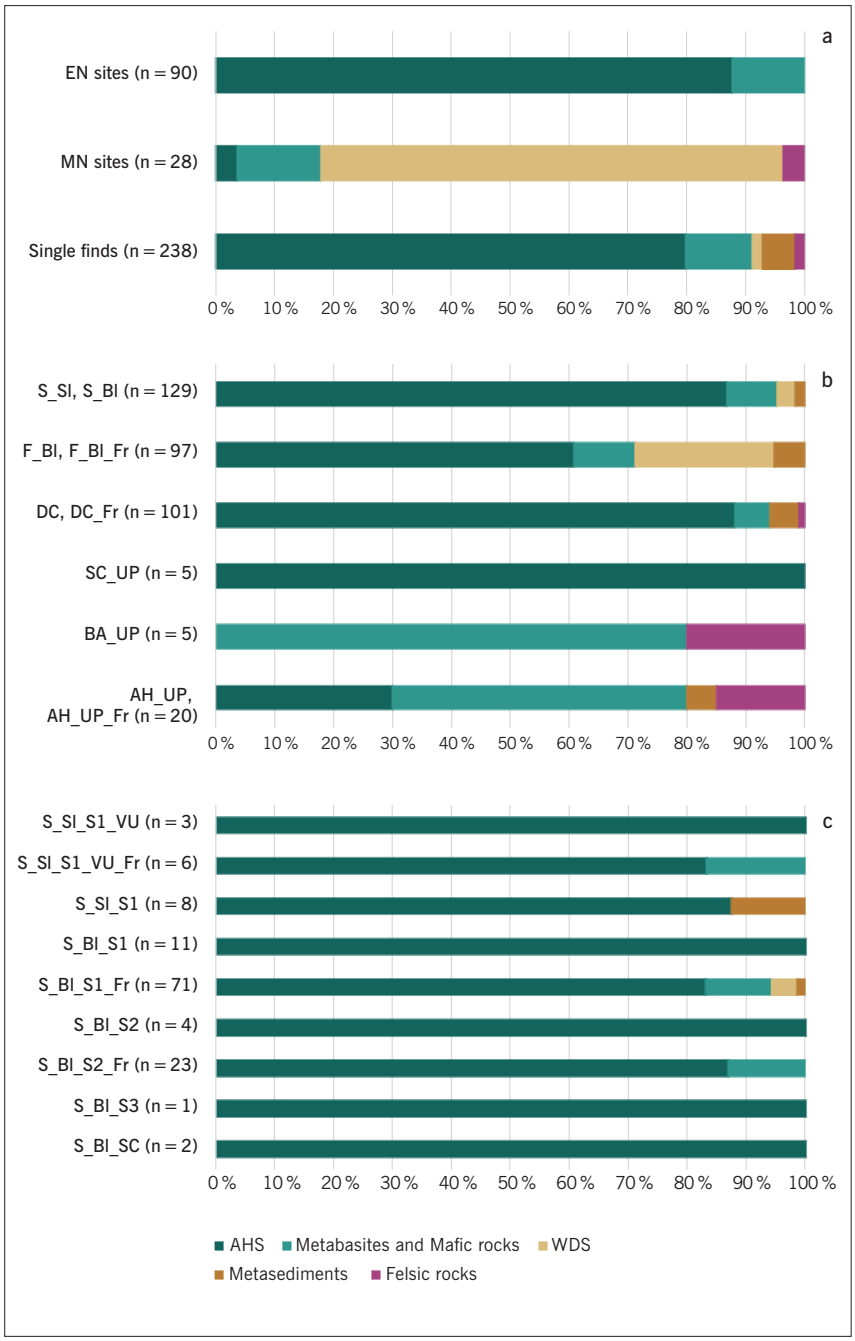


Fig. 6a–c Distribution of lithic raw material according to chronology and type of manufacturing remains. a distribution of lithic raw material according to chronology (EN = Early Neolithic; MN = Middle Neolithic; Single finds = undated); b distribution of lithic raw material according to type of manufacturing remains; c distribution of lithic raw material in sawn slabs and axe blanks.

Abb. 6a–c *Verteilung des lithischen Rohmaterials nach Chronologie und Art der Herstellungsreste. a chronologische Verteilung des lithischen Rohmaterials (EN = frühneolithisch; MN = mittelneolithisch; Einzelfunde = undatiert); b Verteilung des lithischen Rohmaterials nach Art der Herstellungsreste; c Verteilung des lithischen Rohmaterials nach gesägten Platten und Rohlingen.*

blanks are abundant in Early Neolithic sites, where AHS is the main lithic raw material used for the production of axes and adzes (cf. Tab. 2).

The drillcores also show a predominant relation with AHS, which represents 85 % of the petrographic identifications among these manufacturing remains (cf. Fig. 6b). This is indirect evidence that they possibly derived from the production of perforated shoe-last celts or Rössen-type adzes, since AHS is marginally represented among the analysed pecked battle axes or other Middle and Late Neolithic perforated axes. The pecked battle axes studied (BA_UP) are not made from AHS (cf. Fig. 6b). Their perforation could explain most of the 15 % of drillcores made of metabasites, metasediments, mafic, and felsic rocks.

Distribution of blanks and manufacturing debris

The spatial distribution of the sawn and flaked axe blanks made from AHS and, rarely, from metabasites in Central Germany clearly shows an intense clustering of remains in a core area between the Weiße Elster River around Zeitz and the Saale River from the north of Jena to around Naumburg (Fig. 7): a flat landscape with dense Neolithic occupation, high-quality soils, and an abundant supply of water and sand necessary for the production of axes. The dense distribution of artefacts found here indicates one production centre for axes and adzes consisting of several workshops, where all phases of the production process took place. This production centre can be dated to the Early Neolithic based on the shape of the sawn and flaked blanks related to axe

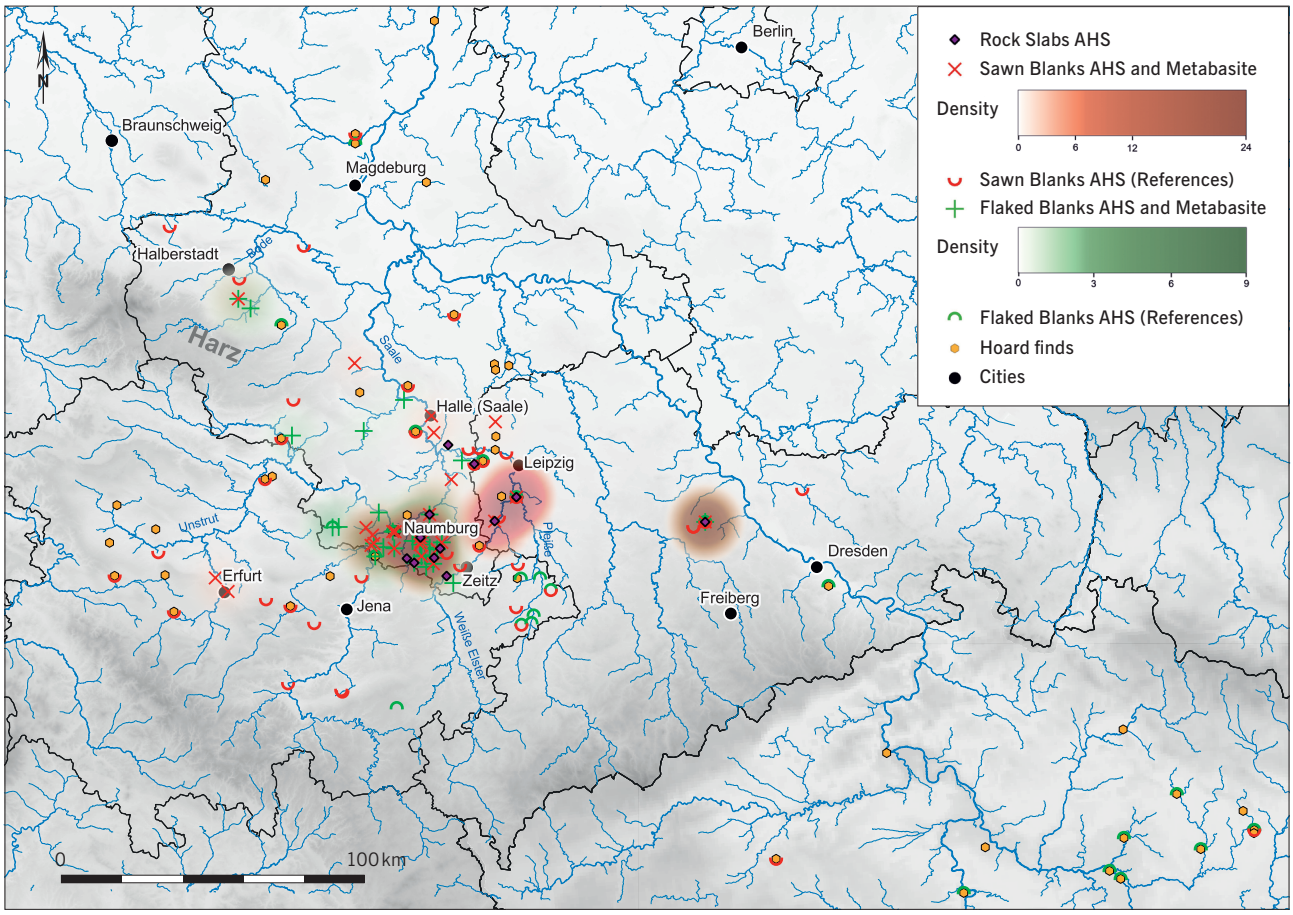


Fig. 7 Spatial Distribution of sawn and flaked axe blanks made from AHS and metabasites in Central Germany. Rock slabs refers to type S_Sl_S1, S_Sl_S1_VU and S_Sl_S1_VU_Fr. References refers to the sawn and flaked axe blanks published by Pietzsch 1951[17]; Kaufmann 1959a[18]; Höckner 1962[19]; Vencl 1975[20]; Küßner 2006[21]; Jansen 2013[22]; Petzold 2013[23]; Kaufmann 2020[24]; Martin 2020[25]. The published blanks refer to the following sites from **Saxony-Anhalt:** Abtlöbnitz[24] (Burgenlandkreis district), Grana[24] (Burgenlandkreis district), Harsleben[24] (Harz district), Hessen am Fallstein[24] (Harz district), Oberschwöditz[24] (Burgenlandkreis district), Oberthau[24] (Saalekreis district), Pölsfeld[24] (Mansfeld-Südharz district), Westeregeln[24] (Salzlandkreis district); **Saxony:** Baderitz[17] (Nordsachsen district), Birmenitz[17] (Meißen district), Cunnersdorf[17] (Meißen district), Leipzig-Wahren[17] (Leipzig district), Wehlitz[24] (Nordsachsen district), Wiederau[17] (Borna district); **Thuringia:** Dittersdorf[18] (Saale-Orla district), Fichtenhainichen[19] (Altenburger Land district), Gößnitz[23] (Altenburger Land district), Gräfentonna[24] (Gotha district), Gröba[19] (Altenburger Land district), Heldrungen[24] (Kyffhäuserkreis district), Hirschroda[25] (Saale-Holzland-district), Isseroda[24] (Weimarer Land district), Leina[19] (Altenburger Land district), Löhmigen[23] (Altenburger Land district), Niedersynderstedt[21] (Weimarer Land district), Nitzschka[22] (Altenburger Land district), Öpitz[18] (Saale-Orla district), Röthenitz[19] (Altenburger Land district), Rudolstadt[18] (Saalfeld-Rudolstadt district), Schlettwein[18] (Saale-Orla district), Windischleuba[19] (Altenburger Land district); **Czech Republic:** Chudonice[20] (Hradec Králové district), Čistěves[20] (Hradec Králové district), Jeřice[20] (Hradec Králové district), Kovanice[20] (Nymburk district), Křinec[20] (Nymburk district), Lípa[20] (Hradec Králové district), Liteň[20] (Beroun district), Lovosice[20] (Litoměřice district), Malá Černoc[20] (Louny district), Nudvojovice[20] (Semily district), Bubeneč[20] (Praha district), Poděbrady[20] (Nymburk district), Štěnovice[20] (Plzeň-jih district), Vitiněves[20] (Jičín district).

Abb. 7 *Verbreitungskarte gesägter und geschlagener Rohlinge aus Aktinolith-Hornblende-Schiefer und Metabasiten in Mitteldeutschland. »Rock Slabs« meint die Typen S_Sl_S1, S_Sl_S1_VU und S_Sl_S1_VU_Fr. »References« bezieht sich auf an anderer Stelle veröffentlichte gesägte und geschlagene Rohlinge bei Pietzsch 1951[17]; Kaufmann 1959a[18]; Höckner 1962[19]; Vencl 1975[20]; Küßner 2006[21]; Jansen 2013[22]; Petzold 2013[23]; Kaufmann 2020[24]; Martin 2020[25]. Die publizierten Halbfabrikate stammen von den folgenden Fundstellen:* ***Sachsen-Anhalt:*** *Abtlöbnitz[24] (Burgenlandkreis), Grana[24] (Burgenlandkreis), Harsleben[24] (Lkr. Harz), Hessen am Fallstein[24] (Lkr. Harz), Oberschwöditz[24] (Burgenlandkreis), Oberthau[24] (Saalekreis), Pölsfeld[24] (Lkr. Mansfeld-Südharz), Westeregeln[24] (Salzlandkreis);* ***Sachsen:*** *Baderitz[17] (Lkr. Nordsachsen), Birmenitz[17] (Lkr. Meißen), Cunnersdorf[17] (Lkr. Meißen), Leipzig-Wahren[17] (Lkr. Leipzig), Wehlitz[24] (Lkr. Nordsachsen), Wiederau[17] (Lkr. Borna);* ***Thüringen:*** *Dittersdorf[18] (Saale-Orla-Kreis), Fichtenhainichen[19] (Lkr. Altenburger Land), Gößnitz[23] (Lkr. Altenburger Land), Gräfentonna[24] (Lkr. Gotha), Gröba[19] (Lkr. Altenburger Land), Heldrungen[24] (Kyffhäuserkreis), Hirschroda[25] (Saale-Holzland-Kreis), Isseroda[24] (Lkr. Weimarer Land), Leina[19] (Lkr. Altenburger Land), Löhmigen[23] (Lkr. Altenburger Land), Niedersynderstedt[21] (Lkr. Weimarer Land), Nitzschka[22] (Lkr. Altenburger Land), Öpitz[18] (Saale-Orla-Kreis), Röthenitz[19] (Lkr. Altenburger Land), Rudolstadt[18] (Lkr. Saalfeld-Rudolstadt), Schlettwein[18] (Saale-Orla-Kreis), Windischleuba[19] (Lkr. Altenburger Land);* ***Tschechische Republik:*** *Chudonice[20] (Okr. Hradec Králové), Čistěves[20] (Okr. Hradec Králové), Jeřice[20] (Okr. Hradec Králové), Kovanice[20] (Okr. Nymburk), Křinec[20] (Okr. Nymburk), Lípa[20] (Okr. Hradec Králové), Liteň[20] (Okr. Beroun), Lovosice[20] (Okr. Litoměřice), Malá Černoc[20] (Okr. Louny), Nudvojovice[20] (Okr. Semily), Bubeneč[20] (Okr. Praha), Poděbrady[20] (Okr. Nymburk), Štěnovice[20] (Okr. Plzeň-jih), Vitiněves[20] (Okr. Jičín).*

types associated with the Linear Pottery and Stroked Pottery Cultures, as well as the Rössen Culture (shoe-last celts or flat adzes), in addition to the Early Neolithic date of artefacts found in the settlements of Zauschwitz, Harth, and Breitenbach.

A single, isolated workshop with sawn and flaked blanks could be located in Saxony, in the area around Birmenitz, around 30 km north of Freiberg (cf. Fig. 7). This workshop might be part of a second production centre but so far only this single workshop could be identified. The settlement of Birmenitz has an approximate size of 0.4 km² (Hottenroth 1903) and can be dated to the Early Neolithic by pottery fragments featuring characteristic ornaments of the Linear Pottery and Stroked Pottery Cultures. Furthermore, shoe-

last celts and flat adzes typical of the Early Neolithic are abundant axe types found in the settlement. The occupation of this site continued during the Middle Neolithic, and even artefacts dated to the Bronze and Iron Age as well as Medieval periods have been found. Evidence for the production of Neolithic axes is present in a total of 27 sawn and flaked axe blanks, with sawing being the dominant production technique. Furthermore, a total of 13 drillcores have been documented on the site, indicating the perforation of the axeheads directly at the workshop.

Sawing is required mainly on metamorphic rocks, which cannot be flaked due to the high deformation and alignment of the minerals in the rock matrix (Weiner 1996). While the Jizera metabasites are rather isotropic (Šída/Kachlik 2009) and therefore suitable for flaking, some of the thin sections of the sawn axe blanks show a high deformation and sigmoidal rock texture. This slightly different texture could lead to different mechanical properties of the rock, which determine the production technique as well as its usability for tools (Moník et al. 2021). Even if the textural and mechanical differences are barely visible in the artefacts and the thin sections, the use of a different production technique indicates that the rock material used for the Central German axe blanks was often not suitable for an overall flaking of the blanks.

The distribution of all known manufacturing remains identified so far in Central Germany provides direct insight into the organisation of axe production (cf. Fig. 7). Slabs with sawing marks, which appear to have been prepared at the »primary« quarry sites, are only found in a specific territory between southern Saxony-Anhalt and western Saxony. It can be expected that these settlements had direct access to the exploited rock deposits, which – based on the geology of the region – must have been found in one or several of the many greenschist outcrops of the central Saxo-Thuringian zone. In this »secondary« manufacturing area, slabs were transformed into blanks by sawing and flaking. These communities also polished part of the half-finished pieces into axes. But most of the blanks seem to have been handed over to a much larger »tertiary« manufacturing region, which included communities living over 50 km to the north and west of the first area. Such a pattern is an effective form to organise a stone axe manufacturing process: While the initial sawing and flaking can be carried out in a relatively short time and require specific expertise, the polishing implies high workloads but can be accomplished by practically any-

Fig. 8 Hoard from Naumburg, Burgenlandkreis district, Vorstädtischer Friedhof, containing flaked and sawn axe blanks as well as finished axes. This hoard represents the complete production process of axes beginning with the initial flaking/sawing (top left, middle, right, bottom second from left), followed by polishing, represented by the semi-polished artefact (bottom right), and ending in a finely polished axe (bottom left).

Abb. 8 *Depotfund vom Vorstädtischen Friedhof in Naumburg, Burgenlandkreis, bestehend aus geschlagenen und gesägten Rohlingen und fertigen Beilen. Die Beile dieses Hortfunds weisen alle Schritte des Herstellungsprozesses auf, vom anfänglichen Abschlagen/Sägen (oben links, Mitte und rechts, unten 2. von links) über das Schleifen (halbgeschliffenes Exemplar unten rechts) bis hin zum sorgfältig geschliffenen Beil (unten links).*

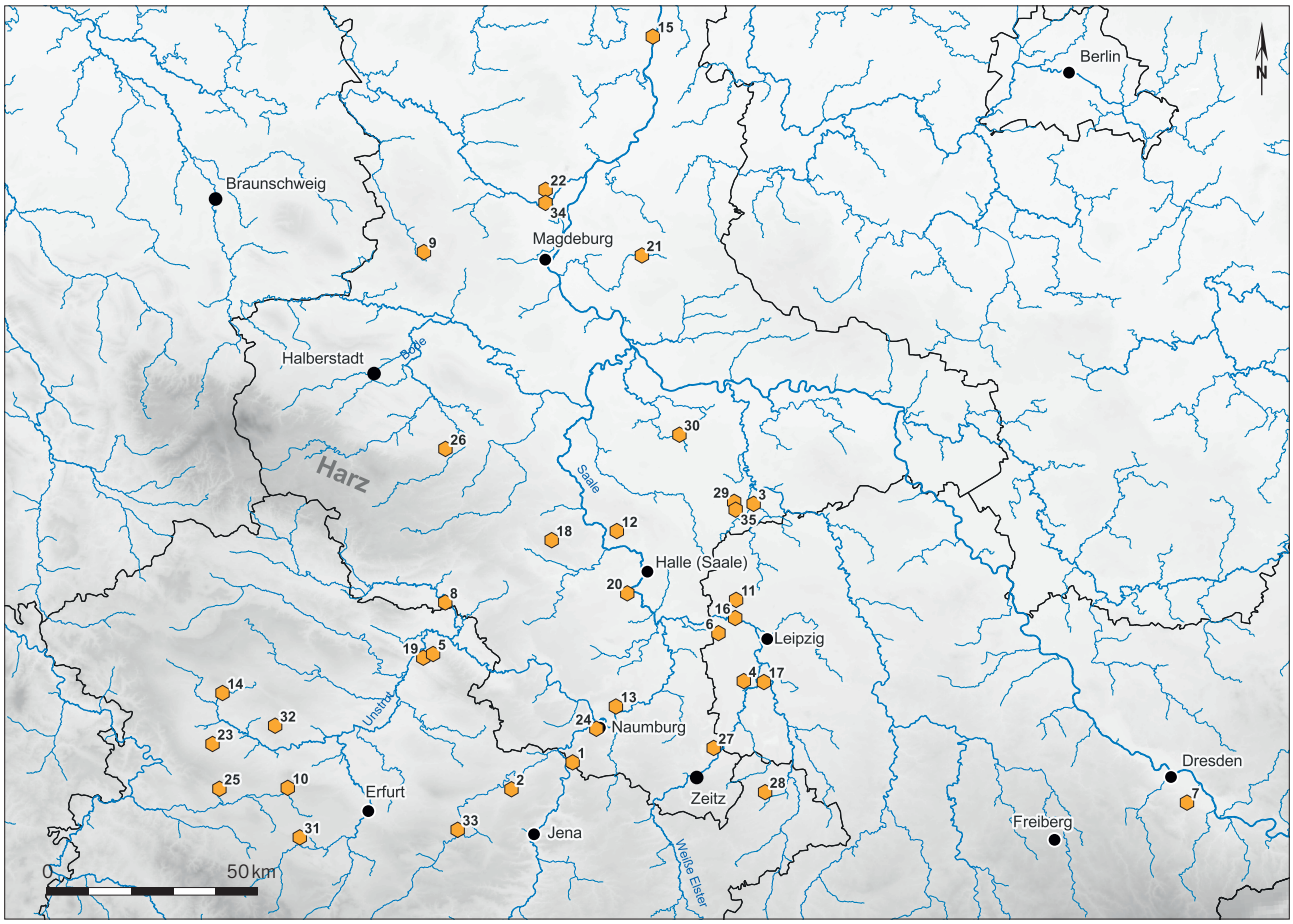


Fig. 9 Spatial distribution of Early Neolithic hoard finds from Central Germany, (1–35, see Tab. 3 for detailed information).

Abb. 9 *Räumliche Verteilung frühneolithischer Depotfunde in Mitteldeutschland, (1–35, detaillierte Informationen siehe Tab. 3).*

one in a community. The dividing of the time-intensive axe polishing processes over a wide territory can be explained as a strategy to increase the production of finished axes. The northward and westward direction of the secondary manufacturing area also points in the direction where the axes and adzes were required, whereas the absence of blanks east of the Birmenitz workshop might suggest that these regions were supplied by the Jizera quarry and production area.

Special attention needs to be paid to a group of hoards that, taken together, contain a total of 50 axe blanks. Almost half of the early Neolithic hoard finds in Central Germany contain at least one flaked or sawn blank (cf. Tab. 3; Fig. 7–9). In some cases, the combination of artefacts included in the hoards seems to elucidate the entire axe-production process. The deposit of Zwenkau-Harth, for example, is formed by the already mentioned large rock slab with straight sawing marks, one flaked and one sawn axe blank, and a finished shoe-last celt (Quitta 1955). This combination of sawn and flaked axe blanks together with the corresponding polished axes also appears in the hoard of Naumburg (cf. Fig. 8). Macroscopic inspection of these artefacts suggests that most blanks and finished adzes found in these hoards are made of AHS or different-textured metabasite. In terms of their spatial distribution, it is noteworthy that hoards with axe blanks appear distributed over a larger territory than in settlements (cf. Fig. 9). A 24 cm long AHS blank has even been found in the adze deposit of Kirchditmold, city of Kassel (Kegler-Graiewski 2007, 179). This confirms the exceptional circulation distances and high value of AHS artefacts, both finished and unfinished.

The distribution of axe blanks made predominantly from Wiedaer Schiefer shows a Middle Neolithic production centre consisting of several workshops along the northern line of the Harz (Fig. 10). Here, flaked and isolated sawn axe blanks are abundant in the two Middle Neolithic sites of Halberstadt and Westerhausen. The restricted distribution of this rock type highlights the economic and social changes taking place during the 4th millennium BC, when the use of a multiplicity of local raw materials replaced the supraregional AHS network.

Most drillcores related to the perforation of axeheads are found in the south of Saxony-Anhalt (Fig. 11), which was a densely settled area where most axe blanks are found (cf. Fig. 7). Although drilling could take place at any stage of the use-life of axes, this spatial overlap of manufacturing remains suggests that the perforations for hafting were already prepared in the workshops along the Saale River and probably along the Weiße Elster River, in Saxony, where drillcores have not been mapped so far.

Axeheads with an unfinished perforation (BA_UP, AH_UP) are distributed more to the north of Saxony-Anhalt, and even finds from Brandenburg and Mecklenburg-Vorpommern could be documented. Shoe-last celts with an unfinished perforation are found in the south of Saxony-Anhalt

Nr.	Locality	Dating	Total amount of artefacts (n)	Sawn blanks (n)	Flaked blanks (n)	Blanks (undefined)	Natural rock slab with saw mark (n)	Raw Material	Reference
1	Abtlöbnitz (Burgenlandkreis district)	EN (LBK/SBK)	6		5	1		Greenish to greyish shistose rock	Herrmann 1934; Quitta 1955
2	Apolda (Weimarer Land district)	Neolithic	7			3			Vogel 1973
3	Bitterfeld (Anhalt-Bitterfeld district)	EN (LBK/SBK)	2					Hornblende-rich rocks/Hornblende-schist	Gustavs 1962
4	Bösdorf (Leipzig district)	EN (LBK/SBK)	3					–	Schmidt 1963
5	Braunsroda (Kyffhäuserkreis district)	EN (LBK/SBK)	7		6			–	Quitta 1955
6	Dölzig (Leipzig district)	EN (LBK/SBK)	5	1	3			–	Näbe 1908; Quitta 1955
7	Dresden-Nickern (total of 3 hoards)	EN (LBK/SBK)			1		1	Amphiboleschist	Baumann 1962
8	Edersleben (Mansfeld-Südharz district)	EN (LBK/SBK)	4	2				rock with greenish-grey colour and foliated texture	Quitta 1955
9	Eilsleben (Börde district)	EN (LBK)	3					–	Kaufmann 2002
10	Eschenbergen (Gotha district)	EN (LBK/SBK)	7					Amphibolite	Müller 1968
11	Freiroda (Nordsachsen district)	EN (LBK/SBK)	4					–	Götze 1896; Quitta 1955
12	Gimritz (Saalekreis district)	EN (LBK/SBK)	2	1				–	Schmidt 1959
13	Goseck (Burgenlandkreis district)	EN (LBK/SBK)	3					Amphibolite	Bertemes/ Northe 2011
14	Grabe (Mühlhausen district)	EN (LBK/SBK)	6					Amphibolite	Hesse 1969
15	Hämerten (Stendal district)	–	3					tough schistose rock	Kupka 1913; Kupka 1931; Quitta 1955
16	Hänichen (Leipzig district)	EN (LBK/SBK)	4					greenish-grey, schistose rock	Quitta 1955
17	Harth (Leipzig district)	EN (LBK/SBK)	4	1	1		1	Diabase/Green-schist	Quitta 1955
18	Hedersleben (Harz district)	EN (LBK/SBK)	5			2		Greywacke, Gneis, quarzitic schist	Marschall 1965
19	Heldrungen (Kyffhäuserkreis district)	EN (LBK/SBK)	4	1				–	Lehmann 1927; Quitta 1955
20	Holleben (Saalekreis district)	EN (LBK/SBK)	8	1	3	1		Hornblendeschist	Götze et al. 1909; Schulz 1939; Quitta 1955
21	Möckern (Jerichower Land district)	EN (LBK/SBK)	11					Slate, green to grey rock with foliation	Quitta 1955 Hoffmann 1955
22	Mose (Börde district)	EN (LBK/SBK)	3	2				fine grained blueish-black rock	Schultheiß 1875; Dunker 1931; Schulz 1939; Quitta 1955
23	Mülverstedt (Unstrut-Hainich district)	EN (LBK/SBK)	2					Blueish-grey rock material	Kaufmann 1959
24	Naumburg (Burgenlandkreis district)	EN (LBK/SBK)	9	1	6			Blueish-grey rock material	Herrmann 1926; Herrmann 1934; Quitta 1955
25	Oesterbehringen (Wartburgkreis district)	EN (LBK/SBK)	4	1				light green shistose rock	Wagener 1928; Quitta 1955

Nr.	Locality	Dating	Total amount of artefacts (n)	Sawn blanks (n)	Flaked blanks (n)	Blanks (undefined)	Natural rock slab with saw mark (n)	Raw Material	Reference
26	Radisleben (Harz district)	EN (LBK/SBK)	4					–	Quitta 1955
27	Reuden (Burgenlandkreis district)	EN (LBK/SBK)	3	1				greenish-grey, schistose rock	Wilcke 1925; Quitta 1955
28	Rositz (Altenburger Land district)	EN (LBK/SBK)	8					Amphiboleschist	Frauendorf 1940; Quitta 1955
29	Sandersdorf (Anhalt-Bitterfeld district)	EN (LBK/SBK)	4					–	Quitta 1955
30	Scheuder (Anhalt-Bitterfeld district)	EN (Rössen?)	4					–	Schmidt 1969
31	Seebergen (Gotha district)	EN (LBK/SBK)	3	1				Amphibolite	Hennig 1963
32	Sundhausen (Gotha district)	EN (LBK/SBK)	3					Amphibolite	Vogel 1973
33	Vollersroda (Weimarer Land district)	EN	3	2				AHS[18]	Küßner/ Neumann 2008
34	Wolmirstedt (Börde district)	EN (LBK/SBK)	4		1			greenish-grey, schistose rock	Schultheiß 1875; Quitta 1955
35	Zscherndorf (Anhalt-Bitterfeld district)	EN (LBK/SBK)	2					Hornblende-rich rocks/ Hornblendeschist	Gustavs 1962
	TOTAL		**172**	**15**	**26**	**7**	**2**		

Tab. 3 Hoards from Saxony-Anhalt, Saxony, and Thuringia often contain axe blanks. Due to the insufficient description of manufacturing traces in some publications, some blanks could not be defined clearly and have been categorised as »blanks (undefined)«. However, as sawing leaves easily recognisable marks, such marks would probably have been noted in the blank description. Therefore, it is to be assumed that these undefined blanks refer to flaked blanks. The total number of artefacts refers only to edge-ground tools and axe blanks.

Tab. 3 *Depotfunde aus Sachsen-Anhalt, Sachsen und Thüringen enthalten oft Beil- und Axtrohlinge. Aufgrund der unzureichenden Beschreibung der Herstellungsspuren in manchen Publikationen konnten einige der Rohlinge nicht eindeutig definiert werden und wurden als »blanks (undefined)« bezeichnet. Da das Sägen jedoch leicht erkennbare Spuren hinterlässt, wären solche in der Beschreibung vermutlich genannt worden. Deshalb kann man davon ausgehen, dass sich diese undefinierten Rohlinge auf Rohlinge mit Abschlägen beziehen. Die Gesamtzahl der Artefakte bezieht sich lediglich auf Werkzeuge mit geschliffener Schneide und auf die Rohlinge.*

but cannot be assigned with the Early Neolithic production centre. Where these partial perforations took place and why they were left unfinished remains unresolved. Maybe, drilling patterns were marked on axes or shoe-last celts in the production centres as an aid for an eventual future modification of their use or as a way to facilitate hafting, an option which, however, was not always chosen.

Conclusion

The study of 357 axe blanks and other production remains from Central Germany has allowed us to identify two axe production centres (one Early Neolithic and one Middle Neolithic) as well as one Early Neolithic workshop. The most important and extensive production centre is located in southern Saxony-Anhalt and western Saxony, between the Saale and White Elster Rivers, a region of ca 1000 km² between the modern cities of Leipzig and the north of Jena in Thuringia. The main concentration of production remains is found around the present-day city of Naumburg, Burgenlandkreis district (cf. Fig. 7). The workshops of this production centre can be dated to the Early Neolithic but probably continued into the Middle Neolithic. A single Early Neolithic workshop was identified in central Saxony, in the settlement of Birmenitz, 65 km east of Leipzig. In view of the wide distribution of blanks and production remains, axe production appears to have been a decentralised activity. No particular community seems to have had control over the outcrops or the technological knowhow.

Actinolite-hornblende-schist was the dominant raw material processed in these workshops. Other metabasites, such as amphibolite and metadolerite, had a minor importance. Sawing and flaking were the main manufacturing techniques, and they appear combined on many axe blanks. In mineralogical and petrographic terms, these rocks are

18 The original petrographic identification as quartzitic greywacke is not reliable, as confirmed by Mario Küßner, LDA Thuringia. The published photographs allow us to identify the artefacts as a typical greenschist or AHS.

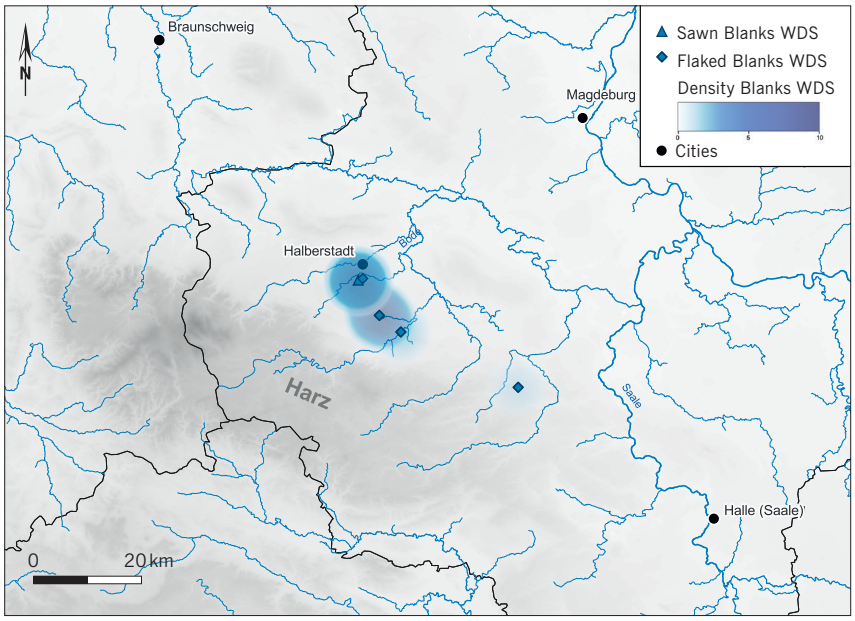
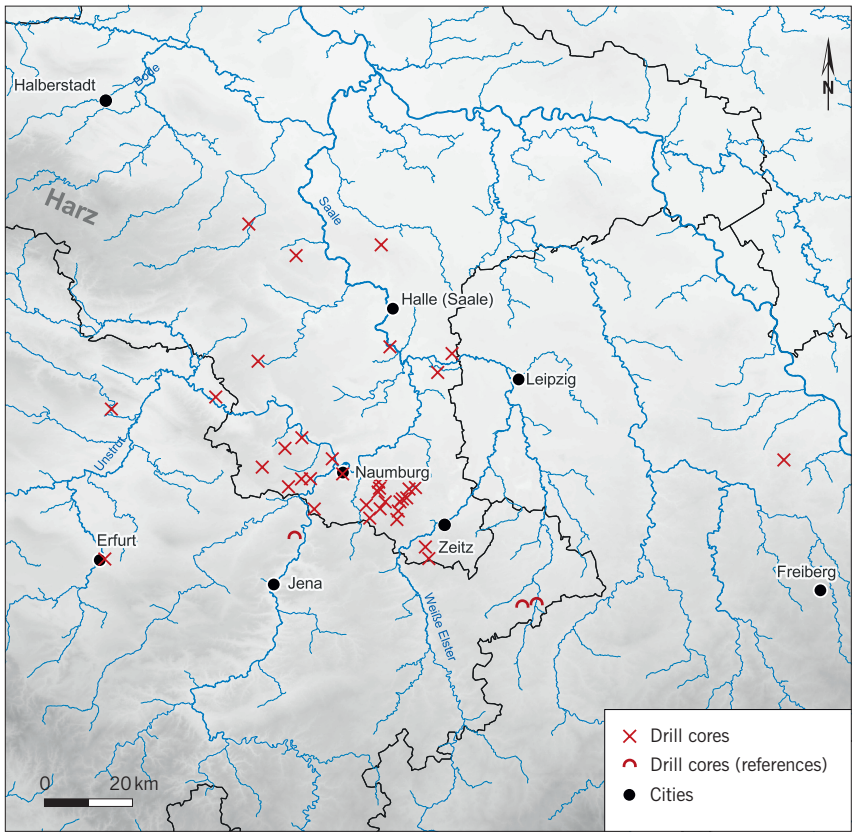


Fig. 10 Spatial distribution of flaked and sawn axe blanks made from Wiedaer Schiefer in Central Germany.

Abb. 10 *Räumliche Verbreitung geschlagener und gesägter Rohlinge aus Wiedaer Schiefer in Mitteldeutschland.*

Fig. 11 Spatial distribution of drill cores kept in the Museum of Halle and the City museum of Naumburg as well as from the studied site of Birmenitz in Saxony. The distribution of drill cores in Saxony and Thuringia is largely unknown.

Abb. 11 *Räumliche Verteilung der Fundorte der Bohrkerne, die im Landesmuseum für Vorgeschichte in Halle und im Stadtmuseum in Naumburg aufbewahrt werden, sowie vom untersuchten Fundort Birmenitz in Sachsen. Die räumliche Verteilung von Bohrkernen in Sachsen und Thüringen ist weitgehend unbekannt.*



highly similar to the material quarried during the Early Neolithic in the Jizera Mountains of Northern Bohemia (Christensen et al. 2006; Ramminger 2007; Šída/Kachlik 2009). The slightly more planar fabric observed in the thin sections of blanks and axes from Central Germany is not sufficient to assume a different geological origin. However, greenschists such as AHS are common rocks in Variscan formations and it is most likely that petrographically similar or even identical outcrops exist in different regions of the Saxo-Thuringian mountain range. In fact, they have been identified by geochemical analyses in the Fichtelgebirge, eastern Bavaria (Christensen et al. 2006, 1653 Fig. 4–5; 11; Ramminger 2007). A notable variety of greenschists has been identified during ongoing fieldwork in the Variscan formations of the upper catchment areas of the Saale, Weiße Elster, and Striegis Rivers. As these outcrops can be easily reached from the identified axe production centres just 30–80 km to the south, it is much more likely that the required AHS was found in one or several of the hundreds of greenschist deposits existing in the Saxo-Thuringian mountain-chain rather than transported over 250–350 km, as the crow flies, from the Neolithic Jizera quarries to the workshops in the White Elster

and Saale Valleys. The Neolithic exploitation of metabasite outcrops in the Saxo-Thuringian mountain-chain is also supported by the dense distribution of flaked and sawn axe blanks along the Pleiße River (south of Leipzig) (cf. Fig. 7). Differences in the materials quarried and in the technology used to process the rocks further supports the exploitation of different greenschist sources. While blocks seem to have been extracted and transformed through flaking in the Jizera quarries, 20–60 mm thick slabs were first sawn into adequate preforms and then flaked and pecked or directly polished into axeheads in the Central German workshops. Evidence of sawing in Eastern Bohemia can be narrowed down to one axe found close to Jizera and exhibited in the Kittel-Museum in Krásná, Cheb district, around 10 km from the quarries, two hoards with axe blanks from Malá Černoc, and Čistěves, in north-western and eastern Bohemia, respectively (Vencl 1975) and five sandstone saws found in Zebrak, Beroun district, c. 140 km south of the quarries (Stolz 2016). The exceptional concentration of axe blanks and production debris in the Neolithic Saale–White Elster region, in contrast to the scarcity of such materials further east, also points to the exploitation of local resources.

In sum, both petrographical and archaeological criteria raise doubts about the current hypothesis that the Jizera quarry was the sole source of greenschist for Central Europe. The characteristic types of Early Neolithic AHS axeheads were definitely produced in the densely settled valleys north of the Saxonian Ore Mountains and the Thuringian Slate Mountains. Nor can it be ruled out that still other workshops existed in the Czech Republic south of this mountain range (Řídký et al. 2012). This production centre does not cast doubt on the dimensions and economic importance of the Jizera quarries of Northern Bohemia, but they do oblige us to revise the current model of a massive, long-distance axe circulation across more than 600 km during the Early Neolithic, covering, in particular, the extensive settlement territory defined by the LBK. Given the number of workshops and deposits containing axe blanks in Southern Central Germany, at least part of the AHS axeheads that have been found west of the Harz Mountains up to the Rhine River and even beyond (Nowak 2008) could have come from outcrops located in the central part of the Saxo-Thuringian Variscan zone, and not from the Jizera quarries. Such a multiplicity of sources would reduce the transport costs involved in axe circulation by a mean of 250 km, which corresponds to the distance between Jizera and Naumburg. A more limited axe circulation from one source also fits more neatly into the present picture of Neolithic exchange networks in Western Europe, where main supply distances beyond 150–250 km were problematic. Except jadeitite/omphacitite/eclogite from the western Alps and epidotised tuff from the Lake District in the north-west of England, rock types rarely represent more than 20 % of the locally used stone axes above ca 250 km from their sources (Risch/Martínez 2008; Delgado-Raack et al. 2020).

It is difficult to explain why Early Neolithic workshops specialised in processing almost exclusively AHS. At least in mechanical terms, this rock has not proven to have superior qualities when compared to other European rocks (Moník et al. 2021). That the production of axes and adzes with other Central European rocks was always an option becomes manifest from the Middle Neolithic onwards, when a larger variety of rocks were exploited. In Central Germany, the workshops identified north of the Harz Mountains led to a reduction in the importance of AHS. They processed the locally available »Wiedaer Schiefer.« Our petrographic studies have revealed that this rock is a homogenous, quartz-rich metasiltstone. It seems to have been collected from secondary deposits in the rivers draining Palaeozoic contact-metamorphic rock units (originally geologically mapped as »Wieder Schiefer« by K. A. Lossen in 1881) and processed within 50 km of this raw material source. Other local axe production centres in Central Germany seem to have used diorite, gabbro, basalt, etc. during the Middle and Late Neolithic, but they also continued to exploit AHS. This diversity of rocks of sufficient mechanical quality to produce adequate axes and adzes offered communities more economic alternatives and partners while simultaneously reducing the transport costs in comparison to those observed in the Early Neolithic.

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Source of figures

1–2 S. Meinecke
3 J. A. Soldevilla, LDA
4 a La Baume 1934, 73 Fig. 4; b Pietzsch 1951, 32 Fig. 2; c Pietzsch 1951, 33 Fig. 4; d Wolfram et al. 2014, 98 Fig. 19
5 S. Meinecke; L. Culí
6 S. Meinecke
7 S. Meinecke; base maps: dsm © GeoBasis-DE/BKG (2023); country borders © EuroGeographics for the administrative boundaries; water bodies European Environment Agency (2016). EU-DEM (raster) – version 1.1, Apr. 2016
8 J. Lipták, München
9–11 S. Meinecke; base maps: dsm © GeoBasis-DE / BKG (2023); country borders © EuroGeographics for the administrative boundaries; water bodies European Environment Agency (2016). EU-DEM (raster) – version 1.1, Apr. 2016
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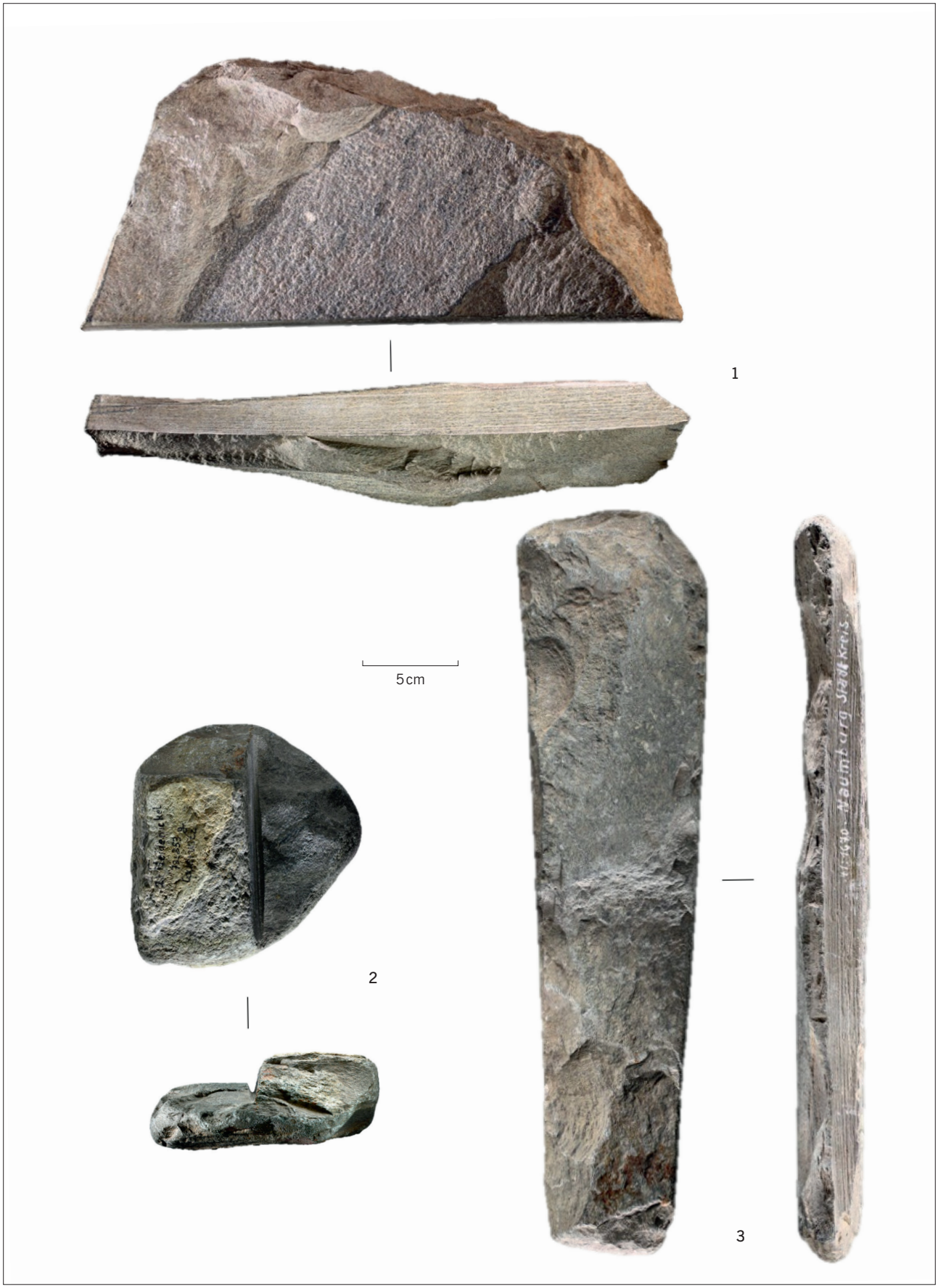
Plates

Plates: Neolithic processed slabs, axe blanks, axeheads with unfinished perforation, and manufacturing debris of Central Germany. The finds are from the State Museum of Prehistory Halle (LV) and the Naumburg City Museum (SM).

Tafeln: Im Neolithikum bearbeitete Steinplatten, Rohlinge, Axtklingen mit unvollständiger Durchlochung und Herstellungsreste aus Mitteldeutschland. Die Funde stammen aus dem Landesmuseum für Vorgeschichte Halle (LV) und dem Stadtmuseum Naumburg (SM).

Plate 1



Pl. 1 1) (LV) 71:810 Günthersdorf, Saalekreis district, natural rock slab with sawing marks (S_Sl_S1); 2) (LV) 73:253g Cauerwitz, Burgenlandkreis district, natural rock slab with unfinished incision (S_Sl_S1_VU); 3) (LV) 41:1670 Naumburg, Burgenlandkreis district, axe blank with sawing mark on one side (S_Bl_S1).

Taf. 1 *1) (LV) 71:810, Günthersdorf, Saalekreis, natürliche Steinplatte mit Sägespuren (S_Sl_S1); 2) (LV) 73:253g, Cauerwitz, Burgenlandkreis, natürliche Steinplatte mit unvollständigem Sägeschnitt (S_Sl_S1_VU); 3) (LV) 41:1670, Naumburg, Burgenlandkreis, Rohling mit Sägespuren auf einer Seite (S_Bl_S1).*

Plate 2

Pl. 2 1) (LV) 48:671 Location unknown (area around Weißenfels, Burgenlandkreis district), axe blank with sawing mark on two sides (S_Bl_S2).

Taf. 2 *1) (LV) 48:671, Fundort unbekannt (Gegend um Weißenfels, Burgenlandkreis), Rohling mit Sägespuren auf zwei Seiten (S_Bl_S2).*

Plate 3

Pl. 3 1) (LV) 16:367 Saaleck, Burgenlandkreis district, axe blank with sawing mark on two sides (S_Bl_S2); 2) (LV) 71:11 Lengefeld, Burgenlandkreis district, axe blank with sawing mark on three sides (S_Bl_S3).

Taf. 3 *1) (LV) 16:367, Saaleck, Burgenlandkreis, Rohling mit Sägespuren auf zwei Seiten (S_Bl_S2); 2) (LV) 71:11, Lengefeld, Burgenlandkreis, Axtrohling mit Sägespuren auf drei Seiten (S_Bl_S3).*

Plate 4

Pl. 4 1) (LV) 92:280e Gerbstedt, Mansfeld-Südharz district, shoe-last celt-shaped axe blank with curved sawing mark (S_Bl_SC); 2) (SM) 1048 Abtlöbnitz, Burgenlandkreis district, flaked axe blank (F_Bl) with visible remnants of the naturally weathered rock surface.

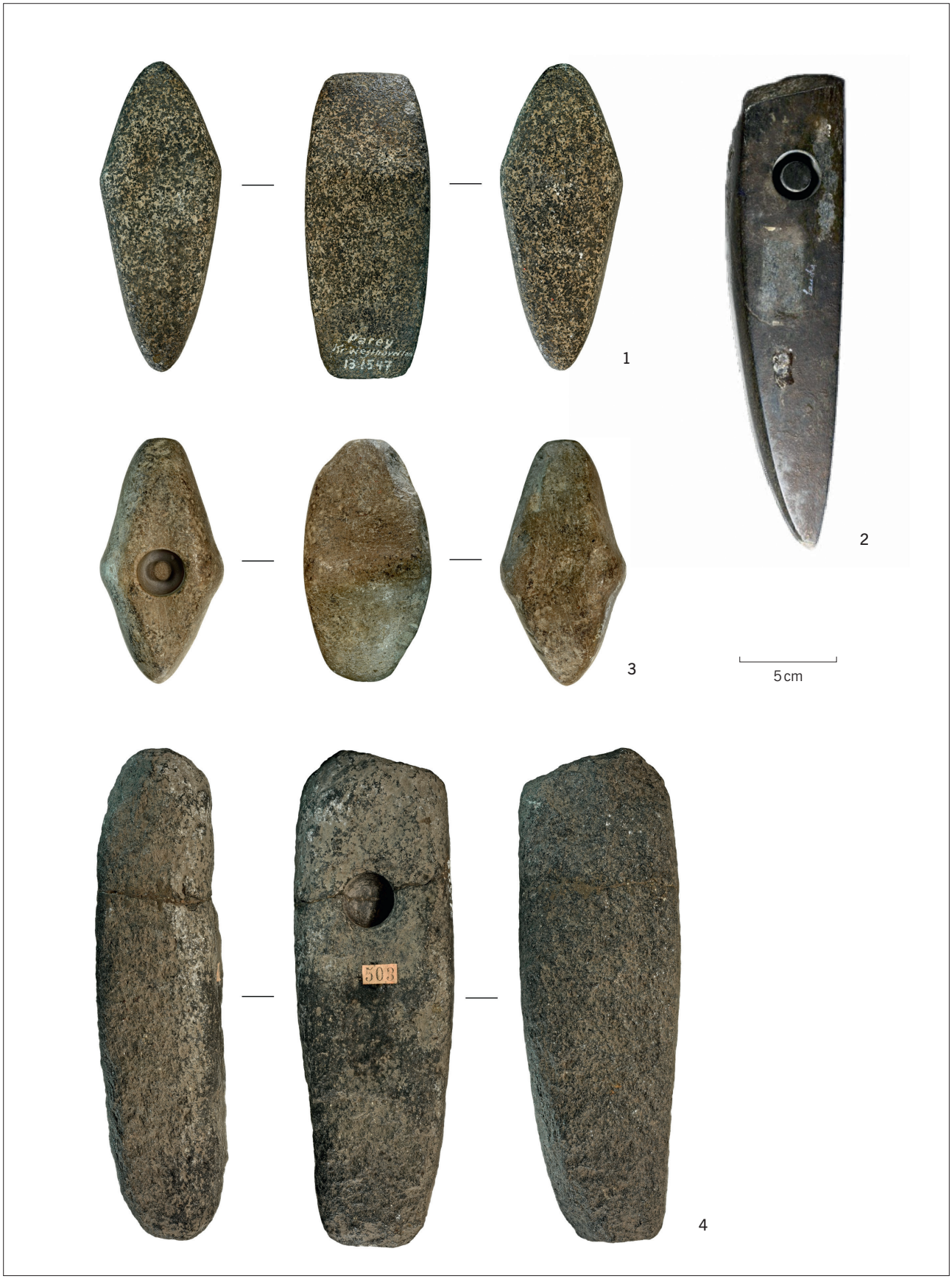
Taf. 4 *1) (LV) 92:280e, Gerbstedt, Mansfeld-Südharz, schuhleistenkeilförmiger Rohling mit gekrümmter Sägespur (S_Bl_SC); 2) (SM) 1048, Abtlöbnitz, Burgenlandkreis, Rohling mit Abschlägen (F_Bl) und sichtbaren Überbleibseln der natürlichen, verwitterten Gesteinsoberfläche.*

Plate 5

Pl. 5 1) (SM) 636 Braunsroda, Kyffhäuserkreis district, flaked axe blank (F_Bl) with visible remnants of the naturally weathered rock surface; 2) (SM) 1473 Naumburg, Burgenlandkreis district, drillcore (DC); 3) (SM) 343 Löbitz, Burgenlandkreis district, drillcore (DC); 4) (LV) 27:97 Durchwehna, Nordsachsen district, battle axe with a pecked surface and no visible traces of a perforation mark (BA_UP).

Taf. 5 *1) (SM) 636, Braunsroda, Kyffhäuserkreis, Rohling mit Abschlägen (F_Bl) und sichtbaren Überbleibseln der natürlichen, verwitterten Gesteinsoberfläche. 2) (SM) 1473, Naumburg, Burgenlandkreis, Bohrkern (DC). Maßstab 1:1; 3) (SM) 343, Löbitz, Burgenlandkreis, Bohrkern (DC). 4) (LV)* 27:97, *Durchwehna, Nordsachsen, Streitaxt mit gepickter Oberfläche und ohne sichtbare Spuren einer begonnenen Lochung (BA_UP).*

Plate 6



Pl. 6 1) (LV) 13:1547 Parey, Jerichower Land district, battle axe with a pecked surface and traces of a mark for the perforation (BA_UP); 2) (LV) 37:30 Heldrungen, Kyffhäuserkreis district, axe-shaped tool with unfinished perforation (AH_UP); 3) (LV) 31:592 Location unknown, axe-shaped tool with unfinished perforation (AH_UP); 4) (LV) 56:525 Laucha, Burgenlandkreis district, shoe-last celt with unfinished hollow perforation (SC_UP).

Taf. 6 *1) (LV) 13:1547, Parey, Lkr. Jerichower Land, Streitaxt mit gepickter Oberfläche und Spuren einer Markierung für die Lochung (BA_UP); 2) (LV) 37:30, Heldrungen, Kyffhäuserkreis, axtförmiges Werkzeug mit unvollständiger Lochung (AH_UP); 3) (LV) 31:592, Fundort unbekannt, axtförmiges Werkzeug mit unvollständiger Lochung (AH_UP); 4) (LV) 56:525, Laucha, Burgenlandkreis, Schuhleistenkeil mit unvollständiger Lochung (SC_UP).*

Neolithic quarrying and archaeological excavations at the Jistebsko site in the Jizerské Hory Mountains

Petr Šída and Pavel Burgert

Zusammenfassung

Neolithische Steingewinnung und archäologische Ausgrabungen am Fundort Jistebsko im Isergebirge

Eine der wichtigsten Quellen steinernen Rohmaterials im frühneolithischen Mitteleuropa stellt der Metabasit am Rande des Isergebirges (tschech. Jizerské hory, Nordböhmen, Tschechische Republik) dar. Dieses Gestein wurde hier in großem Umfang abgebaut und während der gesamten Laufzeit der Linienbandkeramischen Kultur zu Halbfabrikaten verarbeitet. Die am besten erhaltenen Abbauspuren finden sich auf dem Hügel Maršovický vrch im Dorf Jistebsko, wo 25 ha mit Abbaugruben, Halden und Produktionswerkstätten mit Feuerstellen ungestört vorliegen. Dieser Beitrag enthält eine Übersicht der bisherigen Grabungen. Der Umfang des Abbaus und die Menge an Produktionsabfällen entsprechen vielen Hunderttausenden von Halbfabrikaten, die über ausgedehnte Vertriebsnetzwerke bis zu 500 km zurücklegten.

Schlagwörter Neolithikum, Metabasit, Steinbruch, Axt-Halbfabrikat, Werkplatz

Summary

One of the most important sources of raw stone materials for the Early Neolithic in Central Europe – the Jizera Mountains (Jizerské hory) metabasite – is located on the edge of the Jizera Mountains (North Bohemia, Czech Republic). This rock was extensively quarried here and processed into semi-finished products throughout the entire period of the Linear Pottery Culture. The best preserved traces of quarrying can be found on the Maršovický vrch Hill in the Jistebsko village, where 25 ha of intact contexts with quarring pits, dumps, and production workshops with fireplaces have been preserved. The overview of the excavations carried out so far can be seen in this article. The scale of extraction and the amount of production waste is equivalent to many hundreds of thousands of semi-finished products, which travelled up to 500 km through extensive distribution networks.

Keywords Neolithic, metabasite, quarrying, axe semiproduct, workshop

1. Introduction

Raw materials for the production of polished stone tools were an important commodity in European prehistory, spreading over hundreds of kilometres. For the older Neolithic, one dominant raw material has been identified in Central Europe: actinolite- and hornblende-rich metamorphosed schist (AHS), whose source location was sought throughout the twentieth century (Burgert et al. in press). The locations of its origin were established at various places from Central Europe (in Bohemia, see Štelcl/Malina 1970; Bukovanská 1992) to the Balkans (Schwarz-Mackensen/Schneider 1983; Schwarz-Mackensen/Schneider 1986; Schwarz-Mackensen/Schneider 1987). However, the accumulation of production areas and the mineralogy of the rock itself pointed to the Saxothuringian zone, specifically its eastern Bohemian part (Vencl 1975; Přichystal 1985; Přichystal 2000). The aim of this paper is to briefly present, in a broader context, the archaeological activities that have taken place so far at the key site of Jistebsko, North Bohemia (Czech Republic; Fig. 1).

1.1 Localisation

The identified outcrops of metabasite raw materials used are located in northern Bohemia on the southern edge of the Jizera Mountains from the Jeřmanice saddle to Světlá near Tanvald (Czech Republic). This area is 20 km long and about 2–4 km wide.

As the research has already shown, the outcrops of contact metabasites are bound to a narrow contact zone of the Tanvald granite. In the east they can be limited by the Ještrabec Valley near Tanvald. In the west, the Tanvald granite and its metamorphic mantle are tectonically terminated by the Machnín fault in the area of the Jeřmanice saddle (outcrop at Rádlo). The westernmost outcrops of the Tanvald granite are at the south-eastern edge of Pilínkov, a borough of Liberec. The width of the contact metamorphosed zone varies from several hundred metres to one kilometre. The degree of metamorphosis decreases with distance from the contact, with the raw material of the best properties being found only in the zone closest to the contact (up to a distance of about

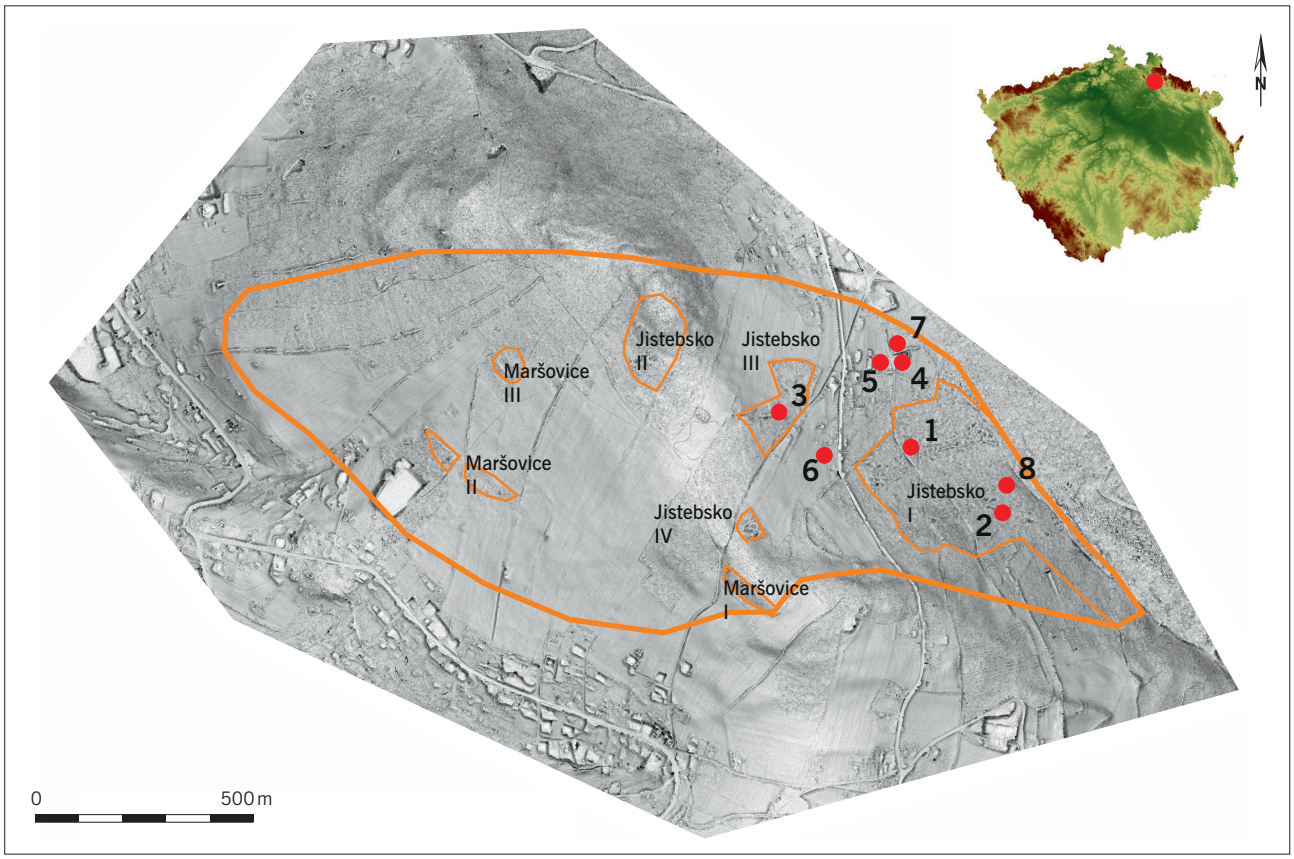


Fig. 1 Jistebsko, North Bohemia (Czech Republic). Location of site and plan of excavations held until now. Legend: areas in narrow orange line: quarrying fields with preserved traces of quarrying; wide orange line: area with a presence of neolithic artefacts; 1 quarrying pit 1, 2002–2012; 2 quarrying pit 2, 2010–2013; 3 quarrying field III; 4 rescue excavation 2009; 5 rescue excavation 2015; 6 rescue excavation 2018–2019; 7 rescue excavation 2022; 8 rescue excavation 2013.

Abb. 1 *Jistebsko, Nordböhmen (Tschechische Republik). Lage des Fundorts und der bisherigen Grabungen. Dünne orangefarbene Linien: Abbauflächen mit erhaltenen Abbauspuren; dicke orangefarbene Linie: Gebiet mit neolithischen Artefakten; 1 Abbaugrube 1, Grabung 2002–2012; 2 Abbaugrube 2, Grabung 2010–2013; 3 Abbaufläche III; 4 Rettungsgrabung 2009; 5 Rettungsgrabung 2015; 6 Rettungsgrabung 2018–2019; 7 Rettungsgrabung 2022; 8 Rettungsgrabung 2013.*

250 m). The highest concentration of raw material is located on the Maršovický vrch Hill in the territory of the municipality of Jistebsko, where most of the explorations have been carried out. This text is devoted to them.

1.2 History of research

The outcrop of amphibole hornfelse (today called metabasite or AHS of the Jizera Mountains type) on Maršovický vrch Hill has been known since the early years of the 20th century. Already at this time, local regional geologists pointed out the striking correspondence of the material with the raw material from which Neolithic tools were made (Huyer 1914; Huyer 1928; Gränzer 1933). However, their work, published in regional journals, was forgotten after World War II. After 1945, many archaeologists and geologists travelled to Maršovický vrch Hill, but no one recorded Neolithic artefacts[1].

Thus, until 2002, we knew that the raw material probably came from Bohemia, most likely eastern or northern Bohemia, but the exact place of origin was not known. The problem was solved independently by V. Šrein (Šrein et al. 2002) and A. Přichystal (2002). Both of them located the raw material outcrops in the Tanvald granite mantle and pointed out the presence of artefacts related to the extraction and processing of this raw material in the Neolithic (5500–4000 cal BC).

The discovery of the largest preserved quarrying field on Maršovický vrch in the area of the village of Jistebsko is connected with the Šrein family. In 2001, during a petrological review of all known metabasite deposits, they discovered extensive remains of unidentified quarrying. Together with P. Šída, archaeological micro-trenches were then excavated in 2002 in the area of quarrying field I, in which the first Neolithic artefacts were found (Šrein et al. 2002).

The surviving surface relics of quarrying turned out to be the remains of metabasite exploitation in the Neolithic. The discovered quarrying area (number I) is approximately 400 x 500 m in size. A much larger area was quarried in pre-

1 Fediuk 1962; Chaloupský et al. 1989; Bukovanská 1992; Kachlík 1997; Klomínský et al. 2005.

Fig. 2 Jistebsko, quarrying pit 1. View from the north-east.

Abb. 2 *Jistebsko, Abbaugrube 1. Blick von Nordosten.*

historic times, but most of it was occupied during the Middle Ages, when it was converted into fields. Later, other surviving quarrying fields were discovered (Jistebsko II–IV, Maršovice I–III). The area with preserved quarrying relics now covers 25 ha. In addition to the quarrying field on Maršovický vrch Hill, other sites have been discovered at Velké Hamry (I and II)[2].

1.3 Raw material name

The raw material represents a rather variable group of hornblende-actinolite-plagioclase (bytownite-labradorite) hornfels, which have been referred to with various names in the past: ironstone (local rock designation), »Actinolithfels« (Huyer 1928), »Nephrite« (Gränzer 1933), amphibolite (Fediuk 1962), »Actinolite-Hornblende-Schists« or »Actinolite-Hornblende-schiefer«, abbreviated as AHS (Schwarz-Mackensen/Schneider 1983; Schwarz-Mackensen/Schneider 1986; Schwarz-Mackensen/Schneider 1987), actinolite hornblende (Bukovanska 1992), green schist (Přichystal 2002), jade (Klomínský et al. 2002), hornblende-plagioclase hornfels (Klomínský et al. 2004), amphibole hornfels (Šrein et al. 2002; Šrein et al. 2003), and Pojizeří type metabasite (Šída 2006).

For simplicity and unification of archaeological nomenclature, in accordance with A. Přichystal (2009, 176–179) we call it a *metabasite of the Jizera Mountains type*.

2. Archaeological research of the Jistebsko site

The total extent of the areas with evidence of raw material processing reaches an impressive 1.5 km². Most of it was also exploited in the Neolithic, but most of this area was converted into fields in the Middle Ages. Undamaged relics of quarrying have thus survived on a total of 25 ha. Archaeological excavation of the surviving quarrying fields has so far been carried out only on the Jistebsko I and III sites, covering a total area of only 111 m², which represents only 0.05 % of the total surviving quarrying area. A further 150 m² have been surveyed as part of rescue excavations during construction in areas that were converted to fields in the Middle Ages (in total, the survey covered about 0.02 % of the entire site). For the moment, the remaining area of the site can only be assessed on the basis of surface collections.

The archaeological research within quarrying field I[3] began in quarrying pit 1 (Fig. 1,no. 1; Fig. 2), where an area of 41.5 m² was excavated using the method of long trenches. It yielded 8800 artefacts (a density of 212 artefacts per m²). A complex stratigraphy with a superposition of several extraction pits (Fig. 3), a concentration of finds in a secondary position in the tailings, and two concentrations related to the presence of an *in situ* workshop were recorded (Fig. 4). No hearth was found here. Two charcoal samples were dated from the pit.

Quarrying here was carried out by means of shallow pits sunk into the hillside extending upslope so that the tailings were deposited down into the already excavated area. The pits often disturbed or completely covered the fills of older pits, which may even be completely filled with younger sediments (in the section presented, this phenomenon can be seen in the southern part). The pits visible on the surface today are thus only a fraction of the total original number.

In the same quarrying field, in its southern part, the excavation of quarrying pit 2 was carried out in 2010–2013 (Fig. 1,no. 2)[4]. This pit was investigated using a 2 m square

2 Prostředník et al. 2005; Přichystal 2002; Přichystal 2009; Šída 2003; Šída 2004; Šída 2005; Šída 2006; Šída 2007; Šída 2007a; Šída 2009; Šída/Kachlík 2009; Prostředník/Šída 2010; Šída et al. 2003; Šída et al. 2012; Šída et al. 2013; Šída et al. 2014; Šída et al. 2014a; Šrein et al. 2002.

3 See the publications by P. Šída and J. Prostředník from 2002–2012 (cf. footnote 2).

4 Research by P. Šída, B. Ramminger, and J. Prostředník.

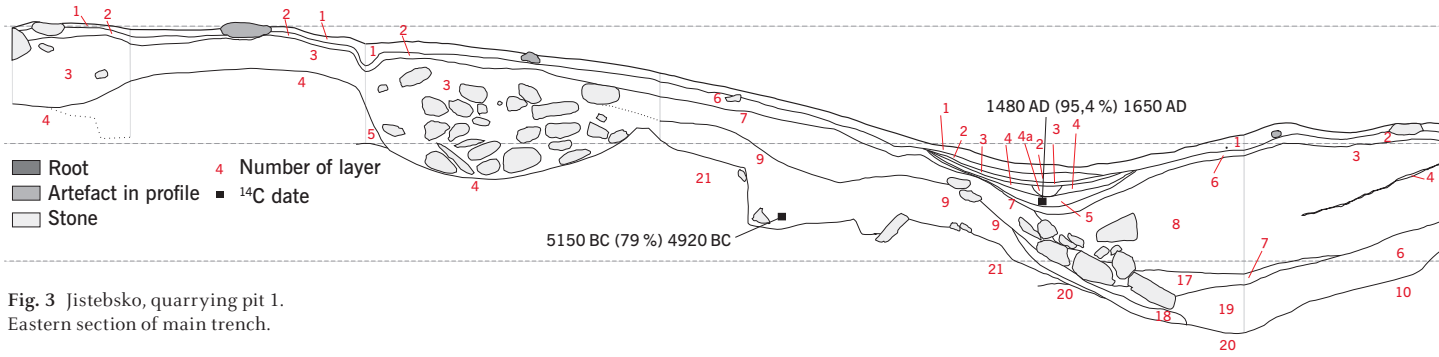


Fig. 3 Jistebsko, quarrying pit 1. Eastern section of main trench.

Abb. 3 *Jistebsko, Abbaugrube 1. Ostprofil des Hauptschnitts.*

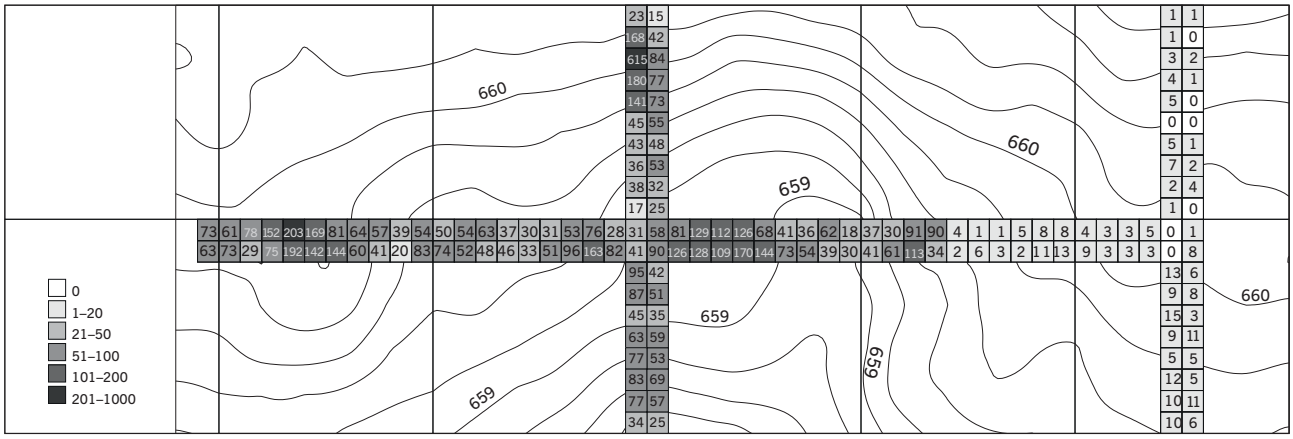


Fig. 4 Jistebsko, quarrying pit 1. Distribution of finds.

Abb. 4 *Jistebsko, Abbaugrube 1. Fundverteilung.*

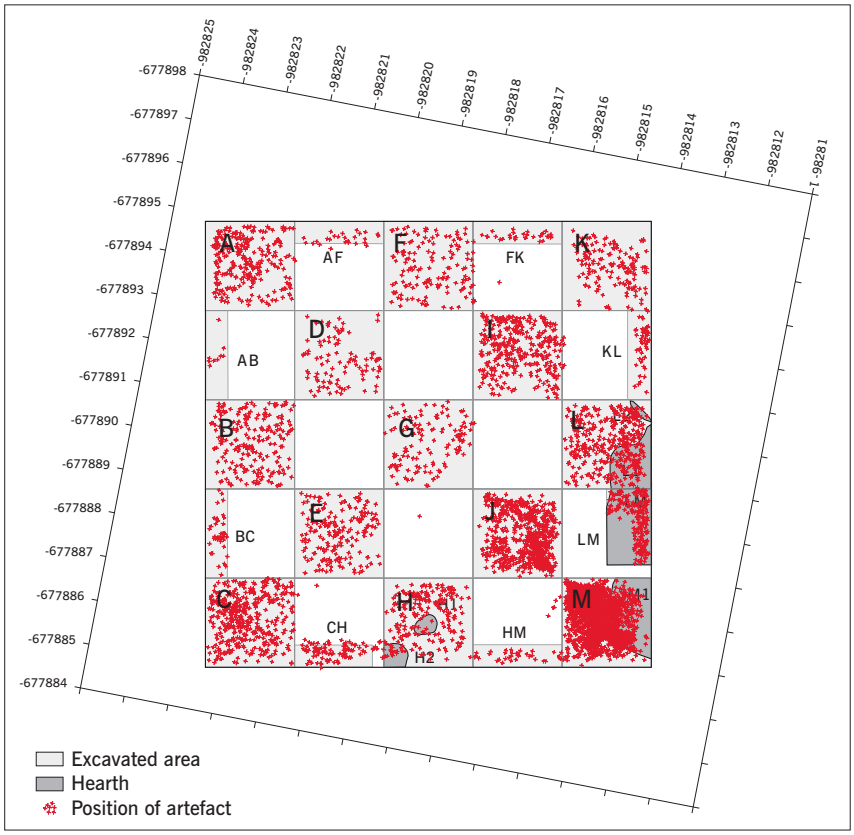
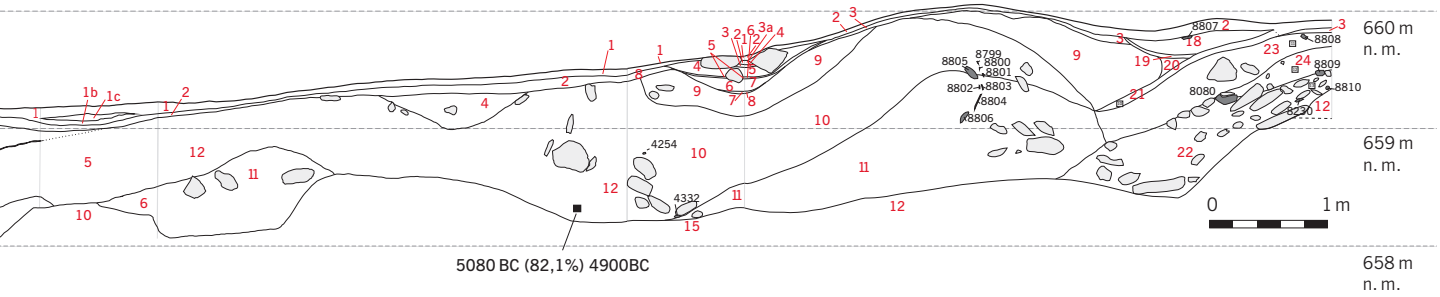


Fig. 5 Jistebsko, quarrying pit 2. Plan of excavation with hearths and distribution of artefacts.

Abb. 5 *Jistebsko, Abbaugrube 2. Grabungsplan mit Feuerstellen und Fundverteilung.*

grid. A total of 5000 artefacts were recovered from the 60 m² surveyed area (Fig. 5; density approx. 80 pieces per m²). In addition to the main extraction pit, the survey recorded several smaller filled test pits, two smaller hearths (one ^{14}C date; see below), and one large complex hearth measuring a total of 6 x 2 m. This hearth has now been dated by nine radiocarbon dates (Fig. 6), indicating repeated long-term use of the site over several centuries (see below).



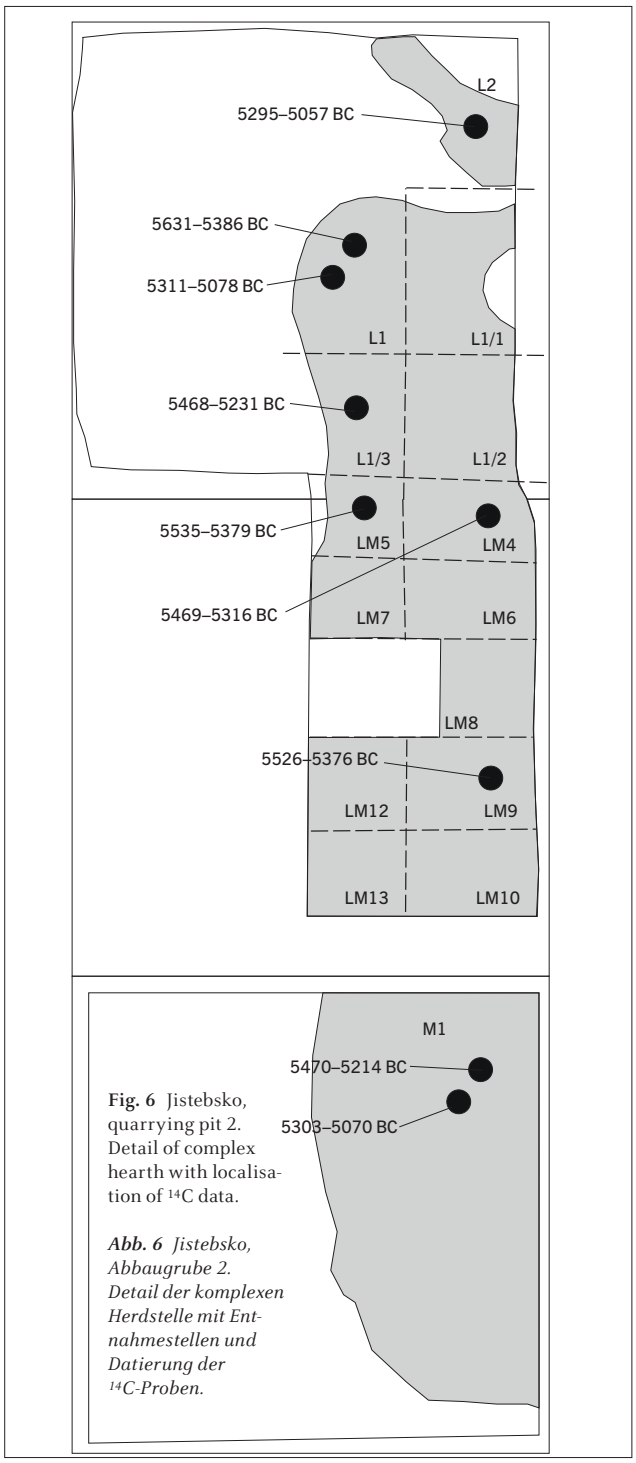


Fig. 6 Jistebsko, quarrying pit 2. Detail of complex hearth with localisation of ^{14}C data.

Abb. 6 *Jistebsko, Abbaugrube 2. Detail der komplexen Herdstelle mit Entnahmestellen und Datierung der ^{14}C-Proben.*

The hearth is overlain by a layer of tailings from the final phase of quarrying (Fig. 7).

The exploratory research in the Jistebsko III quarrying field started in 2012 (Fig. 1, no. 3)[5] and was completed in 2023. Here we came across the core of the site, where the primary source was probably quarryied using deep shafts (in other positions, rubble was extracted from the slopes). A 6 m² probe and several survey microtrenches totaling 3.25 m² captured several *in situ* workshops, the largest of which (in trench 1/12) yielded 16 000 artefacts (ca. 2700 pieces per m²) (Fig. 8). The workshops are typically manifested at the site by a layer of manufacturing waste piled in a more or less circular shape, with a hearth burning in the centre. The formation of these accumulations is the result of the relatively short-term actions of a few chippers who sat down around the hearth and chipped semi-finished products from the prepared raw material. They then deposited the production waste in the hearth area in front of them. The layer of waste captured by this trench is up to 30 cm thick and consists almost entirely of chipped artefacts with minimal sediment. The workshop is chronologically classified by a single radiocarbon date.

Below the workshop we found the edge of a quarrying shaft (Fig. 9) broken out into the growing rock. We do not know its size or depth at this time, but, given the dip of the metabasite positions to the north, it will likely be several metres.

Fig. 7 Jistebsko, quarrying pit 2. Close-up view of the fireplace covered with tailings in the LM sector.

Abb. 7 *Jistebsko, Abbaugrube 2. Nahaufnahme der mit Abraum bedeckten Feuerstelle im Sektor LM.*

5 Research by B. Ramminger, P. Šída, and J. Prostředník.

Fig. 8 Jistebsko, quarrying pit 3. View of the concentration of workshop waste.

Abb. 8 *Jistebsko, Abbaugrube 3. Blick auf die Konzentration von Werkplatzabfällen.*

Outside of the surviving quarrying areas, the context is preserved in a fragmentary and patchy manner, but this does not mean that it is not preserved at all. Medieval clearance has affected the surface layer, filling in the quarrying pits, but their infill remains intact, and in some places the workshops themselves, or parts of them, survive.

The first of these pits was captured by the first rescue excavation in 2009 on plot number 450 in the village (Fig. 1, no. 4; Šída et al. 2014a). A 20 cm thick layer of production waste containing the hearth itself was explored within a 1.5 m² trench. The 0.6 m² area contained 4000 artefacts. Even without the finds from the cleaning sections and surface in the environs, the density of finds from the industry in this area reaches 3000 artefacts per m² (Fig. 10).

Several other archaeological rescue excavations were carried out not far from the the locations of previous research. In 2015, an entire quarrying pit filled with a layer of workshop waste was excavated, immediately adjacent to the previous lot, on lot 110 (Fig. 1, no. 5). The excavation yielded 3500 larger artefacts and around 25 000 microchips and has so far been dated by a single radiocarbon date (Fig. 11).

Other contexts were captured during a nearby house construction in 2018 and 2019, when two workshop concentrations were explored along with one quarrying pit (Fig. 1, no. 6). This rescue excavation yielded around 5000 artefacts (Fig. 12); the dating is still in progress.

The most recent workshop with a quarrying pit was recorded in 2022 on an area (Fig. 1, no. 7) adjacent to the first rescue excavation of 2009. Over 3000 artefacts were recovered, and the excavation has already been radiocarbon dated (Fig. 13).

One small rescue excavation was also carried out in 2013 in quarrying field I at the site of a logging disturbance (Fig. 1, no. 8). The 1 m² probe reached a depth of 30 cm with 387 artefacts.

During the current research campaign, we are primarily conducting small test trenches to determine the stratigraphy and presence of workshop areals and to obtain dating material. Crucially, the first detailed mapping using a hand-

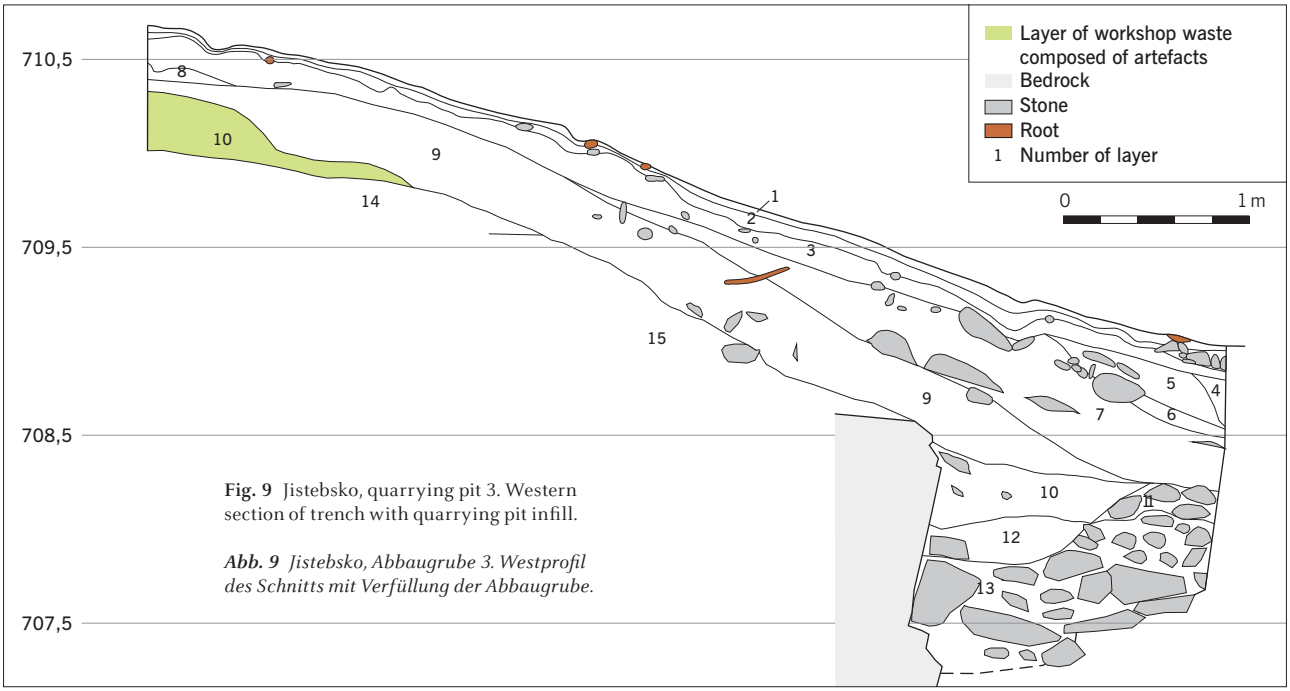


Fig. 9 Jistebsko, quarrying pit 3. Western section of trench with quarrying pit infill.

Abb. 9 *Jistebsko, Abbaugrube 3. Westprofil des Schnitts mit Verfüllung der Abbaugrube.*

Fig. 10 Jistebsko 350/1. Section through workshop with fireplace.

Abb. 10 *Jistebsko 350/1. Schnitt durch einen Werkplatz mit Feuerstelle.*

held lidar scanner has provided the highest quality mapping to date of the accessible locations of the extant quarrying fields.

3. Dating

An overview of the radiocarbon data obtained so far is presented in Table 1. Data from different contexts of quarrying locations in the Jistebsko region have been obtained so far in 18 cases. The intervals after calibration cover the period from 5631 to 4799 BC, which corresponds to the duration from the end of the Young Mesolithic through the whole period of the Linear Pottery Culture (henceforce LBK) to the older phase of the Stroked Pottery Culture. Three dates from the context of a single workshop near a large hearth accumulation within the investigated quarrying pit 2 at Jistebsko indicate an overlap with the end of the Mesolithic before the beginning of the LBK in the area (Young Mesolithic).

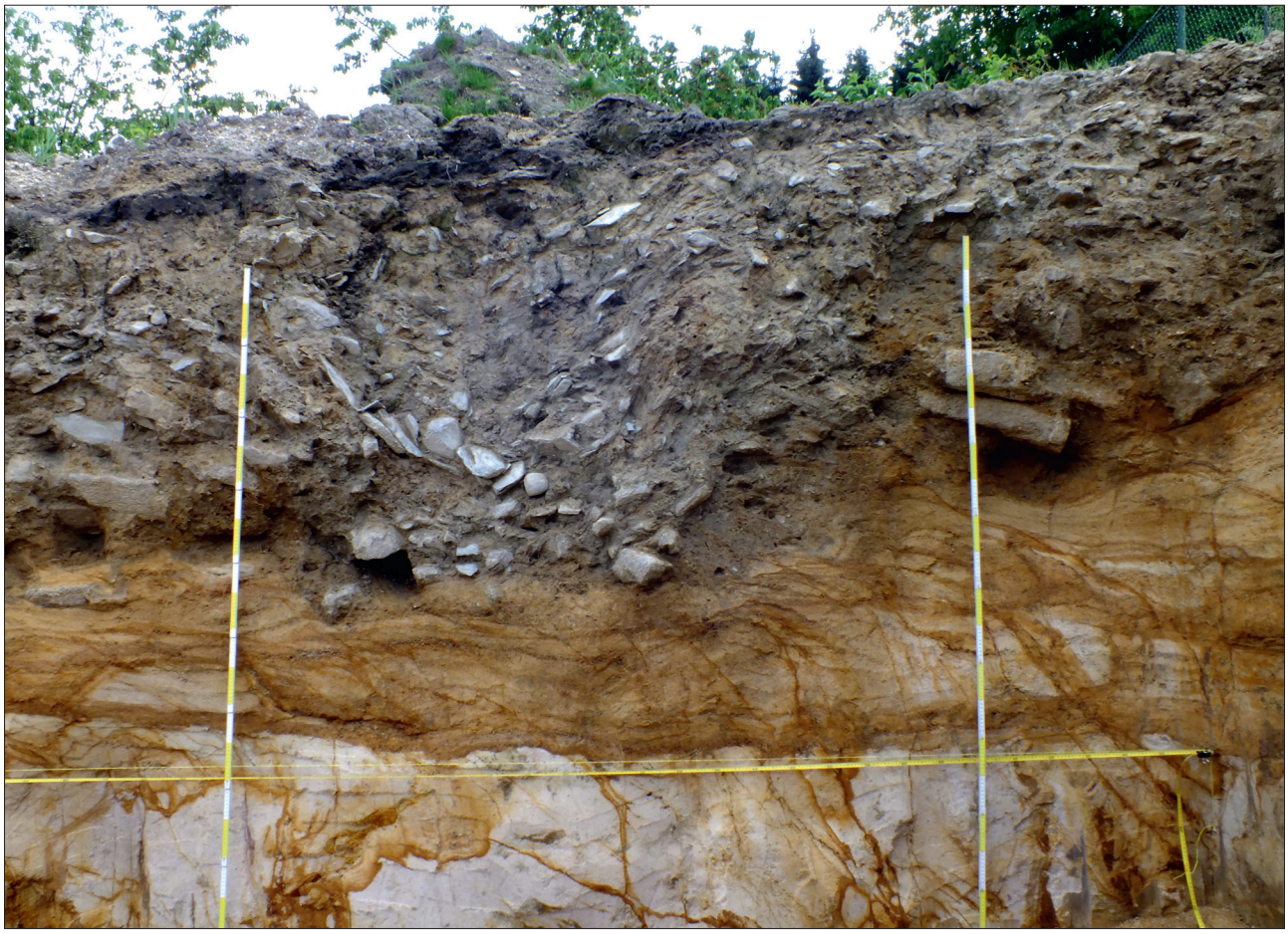


Fig. 11 Jistebsko. Quarrying pit explored during excavations of 2015.

Abb. 11 *Jistebsko. Abbaugrube, die während der Grabungen 2015 untersucht wurde.*

4. Production and technology

Initially, the exploitation of the raw material took place by collecting the raw material on the surface (Mesolithic and probably the beginning of the Neolithic). However, when demand increased with the development of Neolithic society, this was no longer sufficient, so quarrying pits began to be dug on the site. In Bohemia, we have evidence of raw material postprocessing in settlements from the earliest LBK (Burgert 2022). Thus, during a first stage, probably at the point of greatest surface concentration of raw material, extraction eventually progressed to the form of deep shafts extracting the primary body; thereafter, shallow and wide extraction pits probably began to be formed in the hillsides containing blocks of raw material, which gradually progressed to greater distances. This is consistent with the distribution of radiocarbon dates obtained so far, with the latest being found in the peripheral parts.

In the close vicinity of these pits, improvised workshops were created in which semi-finished products of future stone tools (axes) were prepared by chipping. These were then taken from the site to another location for final refinement. The production of semi-finished products by chipping produced huge quantities of production waste: chips and fragments of raw material (cf. Fig. 8), which were left on the site of the workshops or entered secondarily into the

Number	Site	Number of find	Material	Number of laboratory sample	Age BP	Error	Age BC	Dating	Context	Citation
1	Jistebsko I	09.10.02	charcoal	Erl-15826	6574	60	5631–5386	young mesolithic/ neolithic	quarrying pit 2, hearth L1	Ramminger/ Šída 2012
2	Jistebsko I		charcoal short life	UGAMS 10397	6510	30	5535–5379		quarrying pit 2, hearth LM5 (24)	
3	Jistebsko I		charcoal short life	UGAMS 10398	6500	30	5526–5376		quarrying pit 2, hearth LM9 (15)	
4	Jistebsko III	sample 7	charcoal	Poz-90051	6400	40	5471–5317	neolithic	quarrying pit 3	
5	Jistebsko I		charcoal short life	UGAMS 10396	6390	30	5469–5316		quarrying pit 2, hearth LM4 (25)	
6	Jistebsko I		charcoal short life	UGAMS 10394	6360	30	5468–5231		quarrying pit 2, hearth L1/3 (31)	
7	Jistebsko I	09.10.03	charcoal	Erl-15827	6334	59	5470–5214		quarrying pit 2, hearth M1	Ramminger/ Šída 2012
8	Jistebsko	28	charcoal	UGAMS 5279	6270	30	5316–5211		lot 350/1, profil, quarrying pit 2	Prostředník/ Šída 2010
9	Jistebsko I		charcoal short life	UGAMS 9513	6250	30	5311–5078		quarrying pit 2, hearth L1	
10	Jistebsko I	09.10.01	charcoal	Erl-15825	6234	58	5321–5036		quarrying pit 2, hearth H1	Ramminger/ Šída 2012
11	Jistebsko I		charcoal short life	UGAMS 9514	6230	30	5303–5070		quarrying pit 2, hearth M1	
12	Jistebsko	2	charcoal	UGAMS 5277	6210	30	5295–5057		lot 350/1, trench 1, hearth	Prostředník/ Šída 2010
13	Jistebsko I		charcoal short life	UGAMS 10395	6210	30	5295–5057		quarrying pit 2, L2 (6)	
14	Jistebsko	sample 1	charcoal	CRL 22_1980	6186	30	5281–5034		excavation 2022, trench 1	
15	Jistebsko I	1717	charcoal	VERA-2981	6120	35	5209–4957		quarrying pit 1, trench 1	Prostředník et al. 2005
16	Jistebsko	5	charcoal	UGAMS 5278	6100	30	5207–4935		lot 350/1, profil, quarrying pit 2	Prostředník/ Šída 2010
17	Jistebsko I	3834	charcoal	GdA-533	6095	35	5207–4859		quarrying pit 1, trench 3	Prostředník – Šída 2010
18	Jistebsko	146	charcoal, Fraxinus	Poz-90053	6020	40	5011–4799		excavation 2015	

Tab. 1 Jistebsko. Overview of radiocarbon dates obtained in quarrying contexts.

Tab. 1 *Jistebsko. Überblick der Radiokarbondatierungen aus Abbausituationen.*

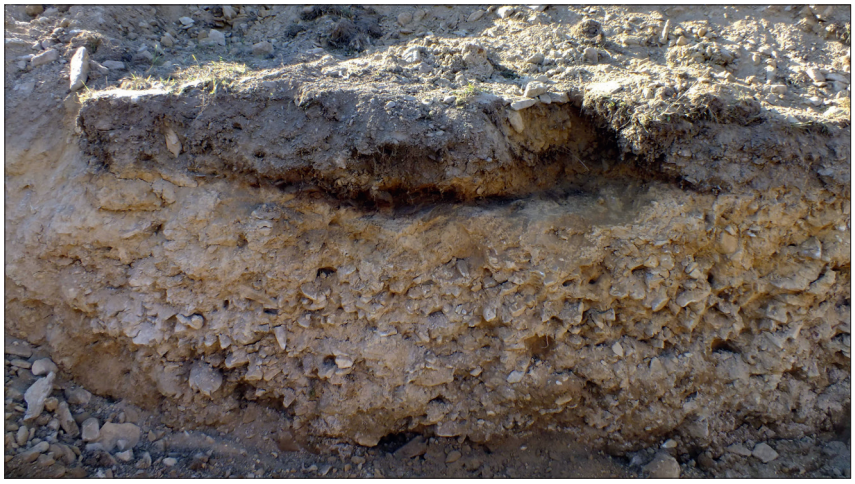


Fig. 12 Jistebsko. Rest of workshop explored during excavations in 2019.

Abb. 12 *Jistebsko. Rest eines Werkplatzes, der während der Grabungen 2019 untersucht wurde.*

Fig. 13 Jistebsko. Workshop explored during 2022 excavations.

Abb. 13 *Jistebsko. Werkplatz, der während der Grabungen 2022 untersucht wurde.*

fills of younger quarrying pits. In addition to the actual quarring, we must imagine some form of temporary short-term settlements on the site.

For the shaping of semi-finished products, chipping is consistently used, which is extremely time-efficient. However, it produces a large amount of waste into which between 30 % and 60 % of the volume of the raw material passes (depending on the specific process). The resulting shape of the semi-finished product is not the result of chance but of a clearly defined forming process. There are basically two production ways.

First way: More complex products come from large blocks of raw material that are prepared by hammering into large cores. In this step, preparatory flakes and amorphous fragments were formed. From these large cores (up to 0.5 m), final flakes as large as 40 cm were chipped. From the flakes, the final shape of the semi-finished product was then retouched by the process of bifacial shortening (bifacial retouching is used to shape the back).

At this stage, flakes and amorphous fragments are produced, with so-called technological retouch in more advanced stages (the flakes or fragments carry the negatives of a large number of previous shaping flakes). The base of the tool, the cutting edge, and the back of the tool are then retouched. The axe-blade retouching may occasionally produce blades. Retouching of semiproducts from large flakes is also evidenced by Kombewa-type flakes (flakes with two bulbs on opposite sides, showing the rebound of the flake from the ventral side of the large flake with the bulb of the primary flake).

Second production way: The simpler technological procedure is not based on a large flake, but on a block of raw material of a suitable shape. The next procedure for preparing the semi-finished product is the same. All stages of production are reflected in the artefacts.

The technology of chipping the semi-finished products took full advantage of the properties of the raw material. It exhibits thin lamination, alternating lamins richer in amphibole with lamins richer in basic feldspars. The blanks are always oriented longitudinally in line with this lamination (the lamination is clearly visible on the corroded surface of the raw material but not on fresh fractures).

A hard hammerstone was used for knaping, as evidenced by the distinctive bullbus visible on the flakes, as well as hammerstones made from the same raw material (metabasite cannot be chipped using any other raw material due to its extreme hardness).

5. Stone industry

The composition of the stone industry assemblages is repeated and corresponds to the workshop form of the site (Tab. 2). The vast majority of the artefacts consist of waste from the production of semi-finished products (amorphous

	Pit 1, trench 1, 2005-6	Lot 350/1, section, 2009	Lot 350/1, layer, 2009	Trench 1/2013	Quarrying pit 2015	Total	%	% Without microchips
Amourphous fragments	595	165	1583	196	2004	4543	13.03	56.97
Amourphous fragments with echnological retouching		2	46	5	19	72	0.21	0.9
Flakes	382	84	1145	140	1116	2867	8.23	35.95
Flakes with technological retouching			120	20	74	214	0.61	2.68
Blades			5		1	6	0.02	0.08
Microchips			1285	6	25590	26881	77.12	
Cores	1				1	2	0.01	0.03
Raw material	32		2	2	14	50	0.14	0.63
Hammerstones	73		2	6	9	90	0.26	1.13
Retouched tools	7	1	4	1	3	16	0.05	0.2
Semiproducts	12	1	22	11	66	112	0.32	1.4
Quarrying tools	2		1			3	0.01	0.04
Total	**1104**	**253**	**4215**	**387**	**28897**	**34856**	**100**	

Tab. 2 Jistebsko. Technotypological composition of selected assemblages.

Tab. 2 *Jistebsko. Technisch-typologische Zusammensetzung ausgewählter Fundtypen.*

fragments, flakes, fragments, and flakes with technological retouch, blades, microfragments). This part of the industry generated up to 99 % of the collections, when microfragments are included, and about 96 % of the collections without them. The remaining small portions of the assemblages are filled with failed semiproducts, cores, probable mining tools (stone moulds resembling blanks adapted to be held directly in the hand and sharpened so that they could be used for digging), and hammerstones. Retouched tools made on flakes resulting from the production of semi-finished axes are represented to a very limited extent. These probably reflect non-productive activities on the site associated with short-term occupation.

6. Conclusions

Maršovický vrch Hill in the Jistebsko region is in many ways an exceptional location. Quarrying here reached enormous proportions, and the degree of preservation of contexts is unique for the older Neolithic period. Archaeological research has been going on here for 22 years and yet we have still uncovered only a small fraction of the preserved contexts. A comprehensive project is currently underway to understand the exploitation, dating, and distribution of this unique Central European raw material.

Quarrying here lasted for at least 500 years, extending throughout the entire LBK. The preserved extent of the quarried area is more than 25 ha, but originally the quarry covered an area of almost 1.5 km². In addition to quarrying, the site was the location for the intensive production of semi-finished products by chipping, which produced an enormous amount of waste material. This is typically accumulated around the hearth, to which production has always been linked. As a result, we are able to recover numerous charcoal assemblages that serve as dating and environmental research material.

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Procurement and circulation of lithic raw materials used for the production of polished stone tools in Lower Silesia (south-western Poland): Some remarks on the state-of-the-art and new research perspectives

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In memoriam Alfred Majerowicz (1925–2018), and Włodzimierz Wojciechowski (1932–2018).

Zusammenfassung

Beschaffung und Umlauf von lithischem Rohmaterial für die Herstellung geschliffener Steinwerkzeuge in Niederschlesien (Südwestpolen): einige Bemerkungen über Forschungsstand und -perspektiven

Dank seiner vielfältigen regionalen Geologie und der reichhaltigen archäologischen Zeugnisse, die mit einer Vielzahl von neolithischen und äneolithischen Gemeinschaften in Verbindung gebracht werden, sollte Niederschlesien als ein sehr interessantes, aber auch besonders anspruchsvolles Gebiet für Provenienzstudien derjenigen Rohstoffe betrachtet werden, die bei der Herstellung polierter Steinwerkzeuge verwendet wurden. Leider besteht in Südwestpolen seit fast zwei Jahrzehnten weitestgehend Stillstand auf diesem Forschungsfeld. In diesem Beitrag werden einem breiteren internationalen Publikum nicht nur die interessantesten Ergebnisse der Untersuchungen vorgestellt, die im 20. Jh. auf diesem Gebiet durchgeführt wurden – sondern auch die vorläufigen Ergebnisse der laufenden Projekte sowie Vorschläge für weitere künftige Forschungsvorhaben unterbreitet.

Schlagwörter Neolithikum, Äneolithikum, geschliffene Steinwerkzeuge, Petrographie, Provenienzstudien

Summary

Thanks to its diverse regional geology as well as rich archaeological record associated with a variety of Neolithic and Eneolithic communities, Lower Silesia should be considered a very interesting but also particularly challenging area for provenance studies of raw materials used in the polished stone tool production. Unfortunately, in south-western Poland this field of research has largely been at a standstill for almost two decades. The aim of this paper is not only to familiarise the wider international audience with a selection of the most interesting outcomes of the 20th century studies conducted in this area but also to discuss preliminary results of the ongoing project and to suggest some further research directions.

Keywords Neolithic, Eneolithic, ground stone tools, petrography, provenance studies

General characteristics and geological setting of the study area

Lower Silesia (Fig. 1) is a historical and geographical region located in the middle Oder River Basin (south-western Poland, Central Europe), bordered by Greater Poland to the north, Upper Silesia to the east, Bohemia and Moravia to the south, and Lusatia to the west. The southern part of Lower Silesia is bounded by the mountain ranges of the Sudetes (with the highest peak Śnieżka 1602 AMSL). To the north-east, the Sudetes are separated from the hilly area of Sudeten Foreland (with the highest peak Ślęża 718 AMSL) by a sharp escarpment attributed to the Sudetic Boundary Fault. The relatively flat Silesian Lowland, located further north, is dominated by glacial or post-glacial landforms and covered with a thick layer of Quaternary deposits.

The Sudetes, belonging to the north-eastern part of the Bohemian Massif (Fig. 2), represent a structural mosaic (Fig. 3), largely formed during the Variscan orogeny. The geological complexes include basement units (Neoproterozoic to Carboniferous) and late- to post-orogenic cover (Lower Carboniferous to Cenozoic deposits). The geologically consistent area of the Sudetes is split into two morphological parts by the Sudetic Boundary Fault. This north-west-south-east-trending feature of Tertiary age separates the mountainous segment from the Fore-Sudetic Block. The basement rocks belonging to the latter part are largely covered by Cenozoic sediments or regoliths and are therefore relatively poorly exposed. The Tertiary tectonic activity was accompanied by widespread basaltic volcanism represented by small isolated outcrops scattered throughout the area between the Sudetic Boundary Fault and the Oder Fault zones.

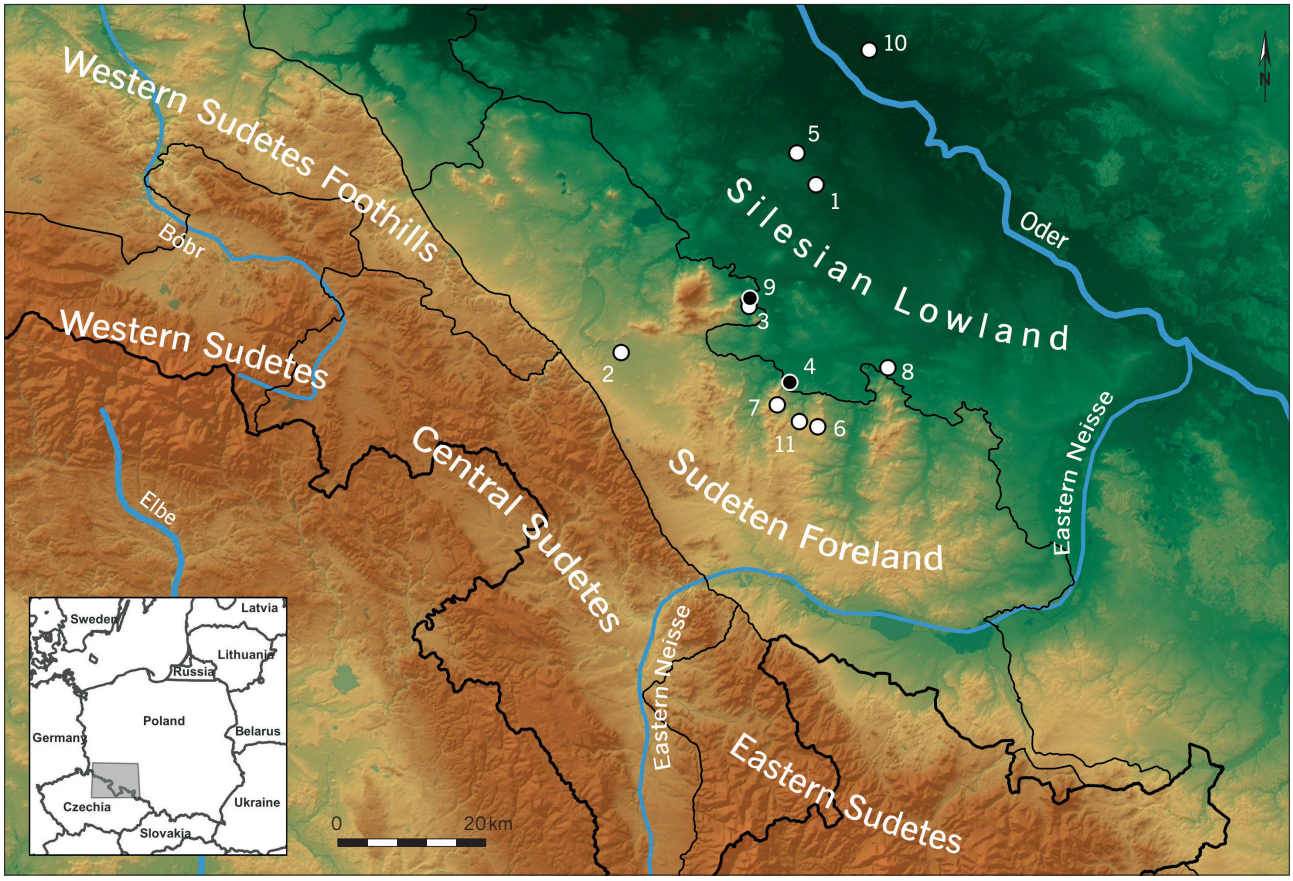

Fig. 1 Map showing major topographic features of the study area and location of archaeological sites. White dots: sites that yielded polished stone tools used in the archaeometric studies; black dots: other sites mentioned in the text. 1 Domasław 10/11/12 (Jordanów Culture); 2 Grodziszcze 7 (Funnelbeaker Culture); 3 Janówek 1 (Funnelbeaker Culture); 4 Księginice Wielkie (Lengyel Culture); 5 Nowa Wieś Wrocławska 4 (Funnelbeaker Culture); 6 Skoroszowice 1 (Linear Pottery Culture); 7 Strachów 2/2a (Linear Pottery Culture, Funnelbeaker Culture); 8 Strzelin 16 (Linear Pottery Culture); 9 Tomice (Funnelbeaker Culture); 10 Wrocław-Widawa 17 (Corded Ware Culture); 11 Zarzyca 6 (Lengyel Culture).

Abb. 1 *Karte der wichtigsten topografischen Merkmale des Untersuchungsgebiets und archäologische Fundplätze. Weiße Punkte: archäologische Fundplätze mit geschliffenen Steinwerkzeugen, die archäometrisch untersucht wurden; schwarze Punkte: andere im Text erwähnte Fundplätze. 1 Domasław 10/11/12 (Jordansmühler Kultur); 2 Grodziszcze 7 (Trichterbecherkultur); 3 Janówek 1 (Trichterbecherkultur); 4 Księginice Wielkie (Lengyel-Kultur); 5 Nowa Wieś Wrocławska 4 (Trichterbecherkultur); 6 Skoroszowice 1 (Linienbandkeramische Kultur); 7 Strachów 2/2a (Linienbandkeramische Kultur, Trichterbecherkultur); 8 Strzelin 16 (Linienbandkeramische Kultur); 9 Tomice (Trichterbecherkultur); 10 Wrocław-Widawa 17 (Schnurkeramische Kultur); 11 Zarzyca 6 (Lengyel-Kultur).*

The systematic detailed geological mapping of the Sudetes and the adjacent Fore-Sudetic Block was already at an advanced stage of completion during the first half of the 20th century. Studies undertaken in this part of the Variscan Orogen are considered crucial to the understanding of many basic issues of Central European geology. Therefore, in recent decades the area has been investigated by numerous Polish as well as multinational scientific projects, which resulted in a constantly growing body of data, including contributions from petrographic, geochemical, and stratigraphic research (for a detailed overview see, e.g., Kryza et al. 2004; Mazur et al. 2006 and references therein).

Particularly important from the perspective of the present paper are mafic and ultramafic bodies belonging to the so-called Central Sudetic Ophiolite (Late Silurian to Early Devonian). These largely consist of gabbroic units and associated serpentinite massifs (namely, the Gogołów-Jordanów, Szklary, and Braszowice-Brzeźnica Massifs) cropping out along the north-eastern, and eastern margin of the Góry Sowie Block (cf. Fig. 3; Mazur et al. 2006, 97).

The long and complex geological history makes the southern part of Lower Silesia not only a very interesting field for petrographic studies, but also a land particularly rich in various mineral resources. These include a wide range of igneous, metamorphic, and sedimentary rocks that have been extensively exploited and used in different branches of human activity throughout the millennia.

A brief overview of the archaeological cultures and settlement patterns to be discussed

During the Neolithic and the Eneolithic, the region of Lower Silesia was inhabited by early agricultural communities associated with a suite of archaeological cultures typical of this part of Central Europe.

The groups of the first farmers that crossed the Sudetic Mountains were associated with the Linear Pottery Culture (LBK, c. 5300–4800/4700 BC) representing the Early Danubian Neolithic agricultural model. The settlement clusters

formed by these communities were closely related to the occurrences of most fertile loess-derived soils. The largest concentration, which covered a significant portion of the Sudeten Foreland as well as an adjacent part of the Silesian Lowland, was located in the interfluve of the Oława and Bystrzyca Rivers (left-bank tributaries of the Oder River; Furmanek et al. 2019, 15–18; Czekaj-Zastawny 2017).

During the 5th millennium BC, the indigenous post-linear communities, attributed to the Stroked Pottery Culture (STK, c. 5000/4900–4450 BC), were subjected to foreign influences and, over time, were gradually replaced by the Lengyel Culture (LC, c. 4600–3600 BC) belonging to the Late Danubian Neolithic. This transformation is believed to have been, at least to some extent, stimulated by the inflow of new colonists from the south. Despite the changes in various aspects of the material culture, the basic rules of settlement and economy that had been established by LBK communities were maintained. This »conservatism« finds its reflection in the continuation of the major settlement clusters. The latest of the Danubian Neolithic communities in Lower Silesia, known as the Jordanów Culture (JC, c. 4300–3600 BC), is considered the first full-fledged Early Eneolithic phenomenon in this area. Due to the lack of any permanent dwelling structures recognisable in the archaeological record, the JC is often believed to have represented a more mobile settlement system, possibly characterised by an increasing role of pastoralism[1].

The emergence of the Funnelbeaker Culture (TRB, c. 3700/3600–3100 BC) brought significant changes to the landscape-use patterns in Lower Silesia. A more versatile settlement system allowed for permanent habitation of previously omitted areas. This is reflected in the archaeological record through a significantly higher density of the recognised TRB sites, as compared to earlier taxonomic units. The changes introduced by TRB communities have also slightly pushed forward the boundaries of settlement clusters. For example, traces of permanent occupation are recognised from the sub-mountainous zone located at the foothills of the Central Sudetes. The overall settlement picture, however, was still largely confined to the left-bank part of the Oder River Basin (Furmanek et al. 2019, 24; Furmanek et al. 2019a, 97–107; Nowak 2017). The trend of expanding the habitation zone initiated by TRB was largely continued by the subsequent Globular Amphora Culture (GAC, c. 3100–2800/2600 BC), even though the settlement network became sparser (Furmanek et al. 2019, 26; Furmanek et al. 2019a, 108–114; Szmyt 2017).

In fact, it was only in the Final Eneolithic period when communities of the Corded Ware Culture (CWC, c. 2800–2400 BC) managed to permanently overcome the remaining ecological barriers and venture into the areas largely omitted by earlier cultures, which is evidenced by numerous archaeological finds in the right-bank part of the Oder River Basin (Furmanek et al. 2019, 27–31; Furmanek et al. 2019a, 115–120; Włodarczak 2017).

Fig. 2 Map showing the position of the study area in relation to the boundaries of the Bohemian Massif. The rectangular shape indicated by the dotted red line outlines the extent of the geological map from Fig. 3, covering a major part of the largest Neolithic settlement concentration in the Sudeten Foreland. The arrows show suggested directions of inflow of stone tools/raw materials from outside Lower Silesia; orange arrows: transportation of metabasites by the Danubian Neolithic communities; blue arrow: transportation of Culmian sedimentary rocks by the Funnelbeaker (and possibly also Lengyel) Culture. For a better orientation, the locations of the major cities are marked with black squares. The crossed hammers symbols show locations of selected raw material outcrops. The black star shows location of the Neolithic workshop in Holasovice, Opava district, Czech Republic.

Abb. 2 *Untersuchungsgebiet im Verhältnis zu den Grenzen des Böhmischen Massivs. Das Quadrat mit der rotgepunkteten Umrahmung entspricht der geologischen Karte von Abb. 3. Es umfasst den Großteil der größten neolithischen Siedlungskonzentration im Sudetenvorland. Die Pfeile geben die vermutete Richtung der Zufuhr von Steinwerkzeugen/Rohmaterialien aus Gebieten außerhalb Niederschlesiens an; orangefarbene Pfeile: Transport von Metabasiten durch die Gemeinschaften des danubischen Neolithikums; blauer Pfeil: Transport von kulmischem Sedimentgestein durch Angehörige der Trichterbecherkultur (und möglicherweise auch der Lengyel-Kultur). Zur besseren Orientierung sind größere Städte mit schwarzen Quadraten angegeben. Die Symbole mit den gekreuzten Hämmern zeigen die Standorte ausgewählter Rohstoffaufschlüsse an. Der schwarze Stern zeigt den Standort der neolithischen Werkstatt in Holasovice, Okres Opava, Tschechische Republik.*

History of the research

The history of petrographic studies on raw materials used for the production of polished stone tools from the Oder River Basin can be dated back to the pre-World War II period, when analyses of selected artefacts were performed by F. Schmitt (Zentralstelle für Petrographische Vor- und Frühgeschichtsforschung at the Mineralogisch-Petrologisches Institut of the Bonn University). The results of the raw material characterisation were used by F. Geschwendt (1941) in the preparation of an article focussing on the prehistoric exploitation of Lower Silesian nephrite.

In the second part of the 20th century, the topic was taken up by Polish academics, including two distinguished scholars from the University of Wrocław: the archaeologist W. Wojciechowski and the petrographer A. Majerowicz. The

1 Czarniak 2012, 37–42; 166–183; Furmanek et al. 2019, 19–21; Furmanek et al. 2019a, 70–96; Kadrow 2017.

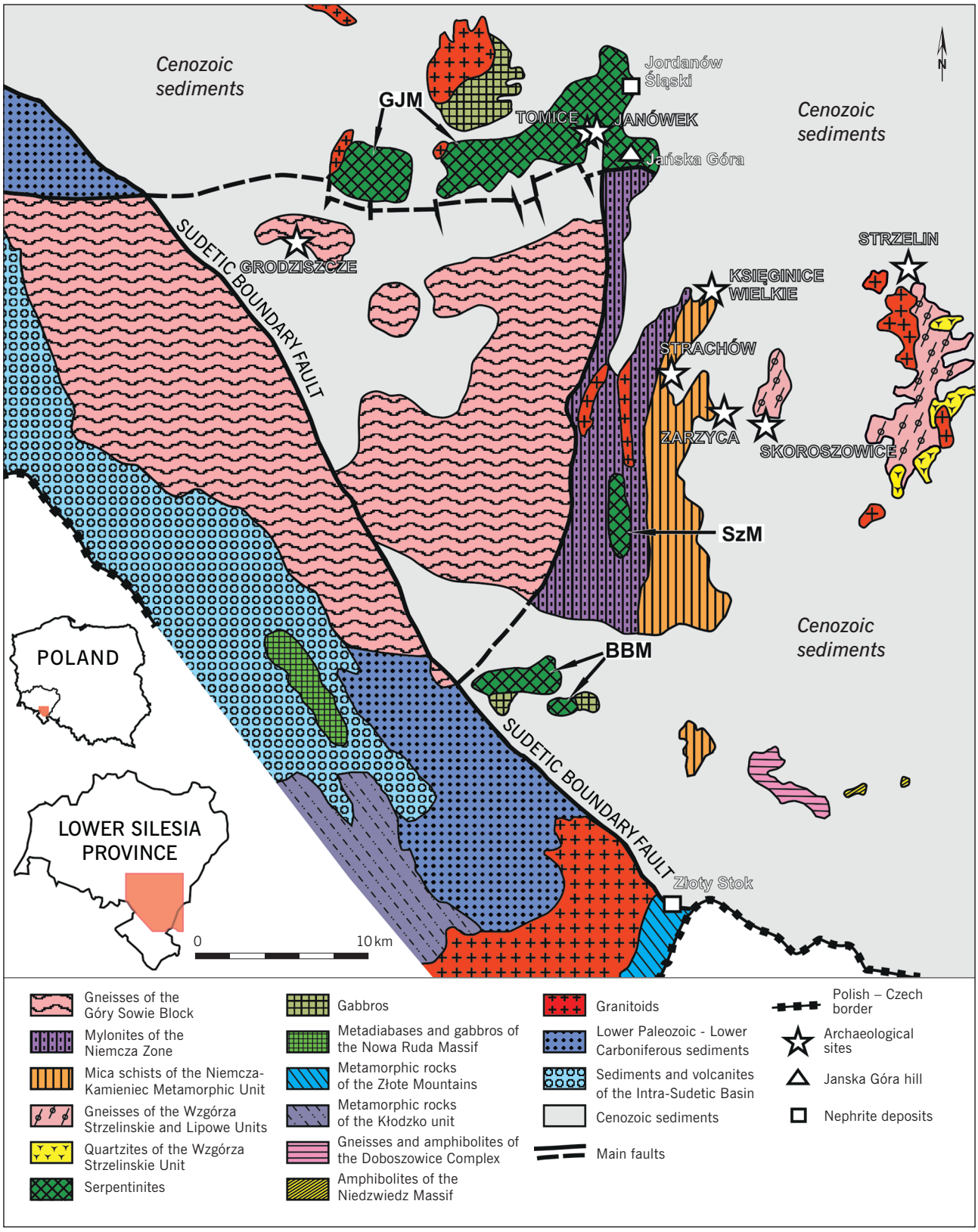

Fig. 3 Geological sketch map showing the surroundings of the Góry Sowie Block. Archaeological sites from Fig. 1 are indicated with white stars. The location of the Jańska Góra Hill with Neolithic quarries excavated by Wojciechowski (1983) is marked with a white triangle. Nephrite deposits are indicated by white squares. Names of the major ultramafic units are abbreviated as follows: BBM – Braszowice-Brzeźnica Massif; GJM – Gogołów-Jordanów Massif; SzM – Szklary Massif.

Abb. 3 *Geologische Kartenskizze der Umgebung des Góry Sowie Block. Die archäologischen Fundplätze aus Abb. 1 sind durch weiße Sterne gekennzeichnet. Die Lage des Jańska Góra mit den von Wojciechowski (1983) ergrabenen Steinbrüchen ist mit einem weißen Dreieck markiert. Nephritvorkommen sind durch weiße Quadrate angegeben. Die Namen der wichtigsten ultramafischen Einheiten sind wie folgt abgekürzt: BBM – Braszowice-Brzeźnica-Massiv; GJM – Gogołów-Jordanów-Massiv; SzM – Szklary-Massiv.*

highlights of their longstanding interdisciplinary cooperation are the discovery of Neolithic serpentinite quarries at the Jańska Góra Hill (Wojciechowski 1983) along with the associated workshop in Janówek, Lower Silesian Voivodeship (Wojciechowski 1973) as well as a detailed study on the collection of Corded Ware Culture battleaxes (Majerowicz 1983; Majerowicz 1985; Wojciechowski 1988).

Since the early 1970s, the umbrella term »petroarchaeology« (Polish *petroarcheologia*, Czech *petroarcheologie*) has commonly been used in East-Central Europe when referring to provenance studies on prehistoric stone tool raw materials (e.g., Janák/Přichystal 2018; Majerowicz et al. 1999; Štelcl/Malina 1975). A range of relevant issues, including Silesian stone axe studies, have been the subject of several international thematic symposia as well as special topic sessions during regional meetings, typically hosted in Poland or the Czech Republic. The results have been published as abstracts and conference proceedings (see Přichystal 2013, 11–12).

The only book aiming to summarise Neolithic stone tool production and distribution in south-western Poland is a monograph written by P. Cholewa (2004). The author made an effort to compile available information on raw materials used for the production of 640 stone implements from Silesia, including both axes and grinding tools. His investigation was largely based on a range of archival reports commissioned over the years by several archaeological institutions. Research sources of this type typically contain only a brief megascopic identification of raw materials from particular sites. More detailed descriptions based on thin section observations, occasionally supplemented by results derived from other analytical techniques (inter alia, X-ray diffraction), are relatively uncommon. The reports used in the study of Cholewa were prepared by the Polish geologists from the University of Wrocław, except the above-mentioned pre-World War II data regarding 32 nephrite artefacts.

During the first two decades of the 21st century, the topic persisted within the scope of interest of Czech academics. The key information on the most important prehistoric raw material types used for the production of polished stone tools from the middle and upper Oder River Basin was comprehensively compiled in a monograph by A. Přichystal (2013), which aims to cover lithic resources from a widely defined area of East-Central Europe. The recent studies of V. Janák and A. Přichystal (2018) focused on stone tools from Upper Silesia. The recognition of changing raw material preferences shed new light on Neolithic social dynamics in this region. Moreover, several raw materials originating from the Sudeten Foreland have been identified, which allowed the authors to make some inferences regarding mutual contacts between the prehistoric societies inhabiting Upper and Lower Silesia.

Unfortunately, at the same time, the petrographic studies on the Neolithic polished stone tools from Lower Silesia conducted by Polish scholars came to a standstill. The exception to this are the raw material characteristics of individual artefacts published in several short reports, typically associated with rescue excavations (e.g., Borowski 2014). More recently, an attempt was made to highlight the archaeological significance of selected raw materials as well as to put forward some hypotheses and suggest further research directions (Borowski 2019).

Rationale of the study and proposition of a new approach

The petrographic research on Neolithic polished stone tools from Lower Silesia has largely been stagnant for almost two decades. At the same time, in Bohemia and Moravia this field of studies has been significantly developed, resulting in some groundbreaking findings, such as the discovery of the prehistoric metabasite quarries in the Jizera Mountains (e.g., Přichystal 2013, 192–195). Undoubtedly, this increase in knowledge puts a new complexion on our understanding of raw material circulation in the widely understood surroundings of the Sudetes, especially during the Early Neolithic period. Therefore, it seems that many conclusions proposed by Cholewa (2004), in particular those referring to the raw material procurement strategies of the Danubian cultures, must be thoroughly revised.

Within the ambit of the ongoing research project, we aim not only to re-examine numerous artefacts covered by 20th century studies but also to investigate some previously unanalysed or incompletely analysed lithic assemblages from regional museum collections as well as those derived from recent excavations. Importantly, some of these insufficiently recognised assemblages include lumps of raw materials, tool preforms, and/or debris indicative of prehistoric production activities. We believe that a closer look at these three categories of objects and contexts in which they were found may significantly contribute to our understanding of spatial relationships between workshops and their geological setting, shedding new light on Neolithic landscape use and the organisation of lithic production. So far, this kind of approach to environmental archaeology has only been attempted once – at a micro-regional scale – with regard to the archaeological site in Janówek and its immediate surroundings (Wojciechowski 1983).

In the course of the present study, all the stone tools were examined using standard megascopic and stereomicroscopic observations. The magnetic susceptibility measurements were performed using a portable magnetic susceptibility meter (a »kappameter«), provided that the size of an artefact is appropriate for this kind of analysis (see, e.g., Přichystal 2013, 45; Trnová et al. 2024, 80). Moreover, from selected stone tools, thin sections were prepared, allowing for detailed petrographic observations through a polarised light microscope. Subsets of stone tools were also analysed using more sophisticated techniques including, inter alia, X-ray diffractometry[2], Raman spectroscopy, scanning electron microscopy (SEM-EDS)[3], electron microprobe exam-

2 X'Pert PRO MPD (Panalytical B.V.); Laboratory of Electron Microscopy, Microanalysis and X-Ray Diffraction; Faculty of Geology, University of Warsaw.

3 Hitachi S-3400N; Laboratory of Electron Microscopy; Faculty of Chemistry, University of Wrocław.

ination[4] of polished thin sections, and bulk geochemical characterisation. During the petrographic classification of rock types, an attempt was made to use the unified terminology, largely consistent with the nomenclature proposed for East-Central Europe (Přichystal 2013). The data will be made available through an online database.

Overview of raw materials

Early Danubian Neolithic

The oldest ground stone tools with edges known from the area of south-western Poland are the Early Neolithic shoe-last adzes attributed to the LBK. Recently undertaken megascopic examination (Přichystal 2013, 195; Janák et al. 2021, 379–380) and archaeometric analyses (Borowski 2014, 448; 450 Fig. 4d; Borowski 2019, 398–399 Fig. 4–6) have shown that raw materials used for the production of these implements are represented almost exclusively by amphibole-rich metabasites, usually showing characteristics consistent with a peculiar variety referred to as Jizerské Hory-type. The geological setting of the metabasite exposures located in the Western Sudetes (e.g., Klomínský et al. 2004; Přichystal 2013, 192–193; Šída/Kachlík 2009) and the archaeological significance of the associated prehistoric open-pit mines (e.g., Přichystal 2013, 190–192; Prostředník et al. 2005) have been exhaustively discussed in the literature. We remind

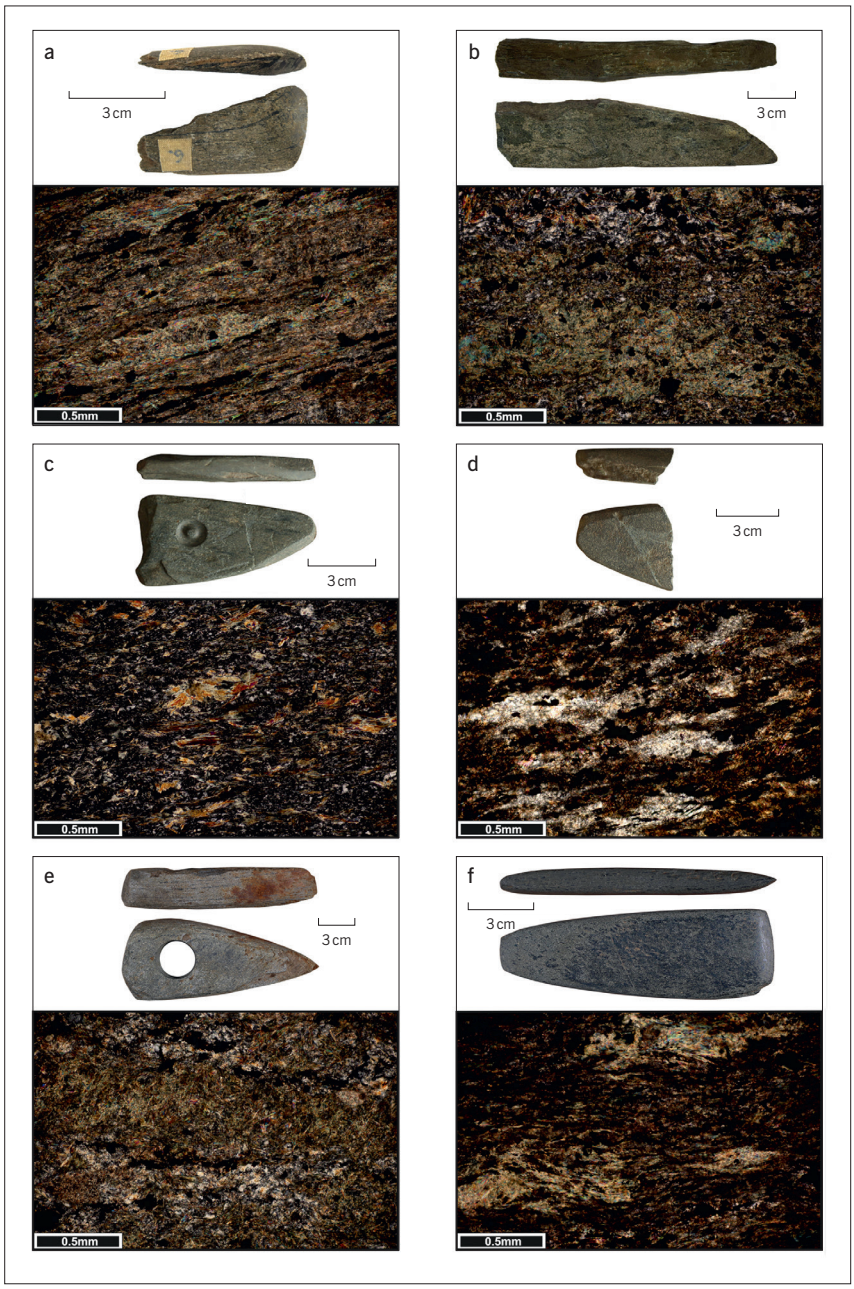

Fig. 4a–f A selection of metabasite artefacts (Danubian Neolithic cultures) along with associated photomicrographs of thin sections (crossed nicols): a adze fragment, Linear Pottery Culture, Jizerské Hory-type metabasite (Strachów 2, ID 497, Institute for Archaeology and Ethnology, Polish Academy of Science in Wrocław); b tool preform, Linear Pottery Culture, Jizerské Hory-type metabasite (Strzelin 16, ID 47, Institute of Archaeology, University of Wrocław); c a significantly reworked shaft-hole axe, Lengyel Culture, Jizerské Hory-type metabasite (Zarzyca 6, ID 146, MAW/6/80, Wrocław City Museum); d a small broken axe fragment, Lengyel Culture, Želešice-type metabasite (Zarzyca 6, ID 81, MAW/1/82, Wrocław City Museum); e shaft-hole axe, Jordanów Culture, Jizerské Hory-type metabasite (Domasław 10/11/12, ID 681, 9g/9h/A/B/13109, Institute for Archaeology and Ethnology, Polish Academy of Science in Wrocław); f axe, Jordanów Culture, Želešice-type metabasite (Domasław 10/11/12, ID 679, 9h/AC/13352, Institute for Archaeology and Ethnology, Polish Academy of Science in Wrocław).

Abb. 4a–f *Eine Auswahl von Artefakten aus Metabasit (Kulturen des danubischen Neolithikums) mit zugehörigen Mikroaufnahmen von Dünnschliffen (gekreuzte Nicol-Prismen): a Dechselfragment, Linienbandkeramische Kultur, Metabasit vom Typ Jizerské hory (Strachów 2, ID 497, Institut für Archäologie und Ethnologie der Polnischen Akademie der Wissenschaften in Breslau); b Rohling eines Werkzeugs, Linienbandkeramische Kultur, Metabasit vom Typ Jizerské hory (Strzelin 16, ID 47, Archäologisches Institut der Universität Breslau); c eine stark umgearbeitete Schaftlochaxt, Lengyel-Kultur, Metabasit vom Typ Jizerské hory (Zarzyca 6, ID 146, MAW/6/80, Museum der Stadt Breslau); d kleines abgebrochenes Axtfragment, Lengyel-Kultur, Metabasit vom Typ Želešice (Zarzyca 6, ID 81, MAW/1/82, Museum der Stadt Breslau); e Schaftlochaxt, Jordansmühler Kultur, Metabasit vom Typ Jizerské hory (Domasław 10/11/12, ID 681, 9g/9h/A/B/13109, Institut für Archäologie und Ethnologie, Polnische Akademie der Wissenschaften Breslau); f Beil, Jordansmühler Kultur, Metabasit vom Typ Želešice/Schöllschitz (Domasław 10/11/, ID 679, 9h/AC/13352, Institut für Archäologie und Ethnologie, Polnische Akademie der Wissenschaften Breslau).*

4 Cameca SX-100; Micro-Area Analysis Laboratory; Polish Geological Institute in Warsaw, Poland.

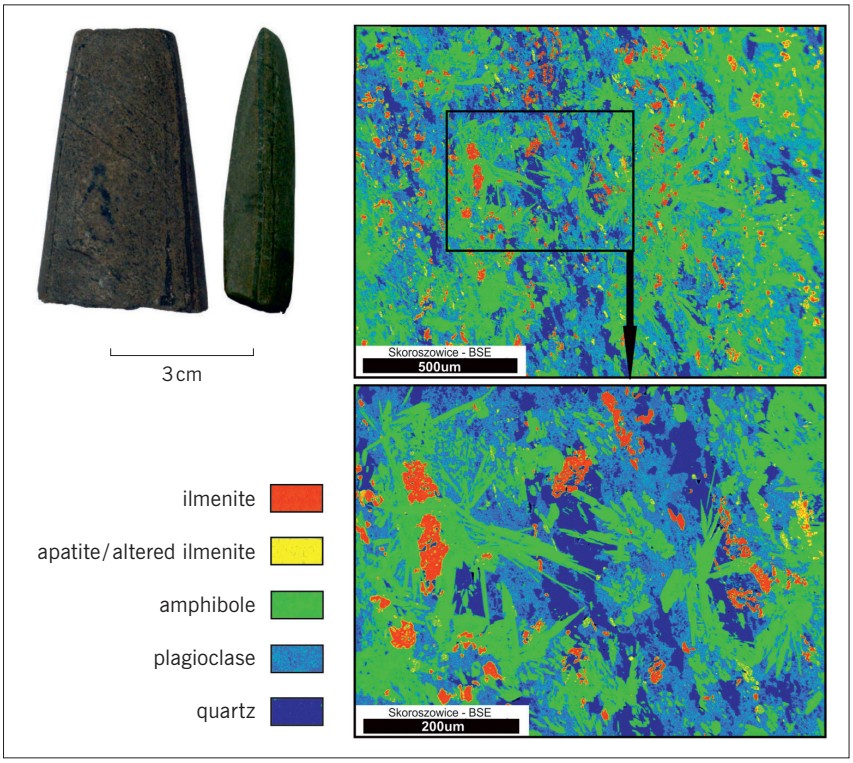

Fig. 5 A broken adze of the Linear Pottery Culture (Skoroszowice, ID 8, Institute of Archaeology, University of Wrocław) and associated false colour BSE images captured via electron microprobe examination of polished thin section. The highlighted details of mineral composition and microstructure are typical of the Jizerské Hory-type.

Abb. 5 *Zerbrochene Dechsel der Linienbandkeramischen Kultur (Skoroszowice, ID 8, Archäologisches Institut der Universität Breslau) und zugehörige Falschfarben-Rückstreuelektronen-Bilder von An- und Dünnschliff mithilfe der Elektronenstrahlmikroanalyse. Die hervorgehobenen Details der mineralischen Zusammensetzung und Mikrostruktur sind typisch für den Typ Jizerské hory.*

our readers that the Jizerské Hory-type metabasites cropping out in the metamorphic envelope of Tanvald granite were extensively quarried in the vicinity of the Jistebsko and Velké Hamry villages (both Jablonec nad Nisou district, Liberec Region; north-western part of the Czech Republic) and were made into stone tools and distributed over large areas of Central Europe. In this paper, we will focus on several aspects of this phenomenon that seem to be particularly important from the Lower Silesian perspective.

It follows from the above that, in terms of raw material preferences, the Lower Silesian LBK did not stand out among other contemporary communities of this culture inhabiting East-Central Europe. The observed unification, however, is inconsistent with results provided by Cholewa (2004, 38–39 Fig. 2), who distinguished several lithological groups used for the production of LBK adzes in south-western Poland. The discrepancy is most likely due to the significant drawbacks of the archival petrographic data compiled by this author. It turns out that, during the 20th century, the raw material in question tended to be either rather imprecisely qualified as amphibolite/amphibole schist based on thin section studies or, even worse, clearly misidentified as metagreywacke/phyllite (allegedly originating from the Eastern Sudetes) following superficial megascopic examination.

The rock is greenish grey or grey to very dark grey on a freshly broken surface and usually bright grey on a patinated surface. A prominent foliation can typically be observed, often accompanied by schistosity and a characteristic alternation of brighter and darker strips. The magnetic susceptibility of this raw material is typically low (< 1.5 x 10-3 SI). Under the polarised light microscope and in the backscattered electron (BSE) images, the rock reveals a nemato-granoblastic texture (Fig. 4a–b; Fig. 5). The preferred orientation is usually expressed by the alternation of layers dominated by acicular hornblende and bright lenses, mainly composed of feldspars and quartz. Ilmenite, often partially altered to leucoxene, is the dominant opaque mineral. The radially arranged needles of amphibole tend to grow irrespectively of the orientation of foliation planes (cf. Fig. 5). This kind of microstructure is believed to be responsible for the excellent mechanical properties of this rock, making it a highly suitable raw material for the production of polished stone tools (Klomínský et al. 2004, 67; Moník et al. 2021; Přichystal 2013, 193).

It seems, however, that the extraordinarily broad distribution of metabasite adzes cannot be explained exclusively on the basis of superior raw material performance (see Moník et al. 2021), given their common occurrence in geologically diverse areas, such as the Sudeten Foreland, offering a wide range of rocks available for lithic production. This indicates that Early Neolithic procurement strategies could have been significantly affected by some indeterminate political, symbolic, or even religious factors. Such phenomena are very difficult to interpret, as they cannot be properly understood when social contexts of production and distribution are not taken into account. In any case, it may be supposed that the exploitation and circulation of Jizerské Hory-type metabasites played a significant integrative role as a means of strengthening trans-Sudetic bonds between the neighbouring LBK communities. Importantly, the ethnoarchaeological evidence provides a range of illustrative examples of »anomalous« stone tool distribution patterns, largely driven by non-economic and non-utilitarian aspects (e.g., McBryde 1984). This kind of information certainly cannot be considered a potential source of definitive answers or even close analogies. It seems, however, that present-day ethnographic knowledge may suggest some new and interesting hypotheses to be tested.

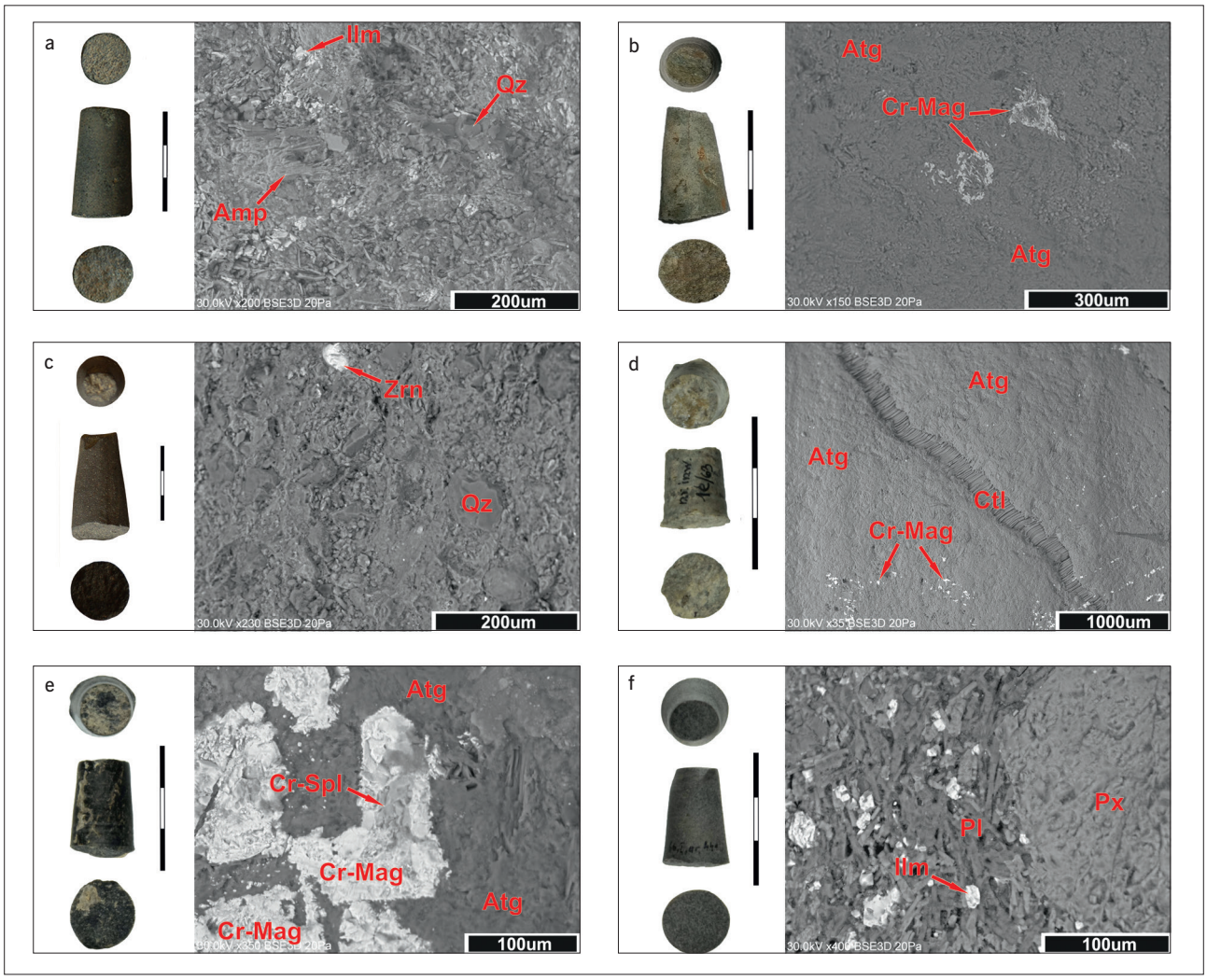

Fig. 6a–f Neolithic drill cores of Lengyel Culture (a–c) and Funnelbeaker Culture (d–f) analysed non-destructively via scanning electron microscopy (SEM-EDS): a metabasite (Zarzyca 6, ID 147, MAW/6/80, Wrocław City Museum); b serpentinite (Zarzyca 6, ID 262, Wrocław City Museum); c mudstone (Zarzyca 6, ID 176, MAW/35/81, Wrocław City Museum); d serpentinite (Janówek 1, ID 668, 1e/63, Institute of Archaeology, University of Wrocław); e serpentinite (Janówek 1, ID 479, DA-MUWR-115/JAN, Institute of Archaeology University of Wrocław); f basaltoid (Janówek 1, ID 478, DA-MUWR-114/JAN, Institute of Archaeology, University of Wrocław). It seems probable that some of these artefacts (in particular: a, c, f) have been derived from stone tool reshaping rather than local axe production, as they represent raw materials not available in close proximity to the respective archaeological sites. Selected details of mineral composition tentatively interpreted from EDS data: Amp – amphibole; Atg – antigorite; Cr-Mag – chromian magnetite; Cr-Spl – chromian spinel; Ctl – chrysotile; Ilm – ilmenite; Pl – plagioclase; Px – pyroxene; Qz – quartz; Zrn – zircon.

Abb. 6a–f *Neolithische Bohrkerne der Lengyel-Kultur (a–c) und der Trichterbecherkultur (d–f) durch Rasterelektronenmikroskopie zerstörungsfrei analysiert: a Metabasit (Zarzyca 6, ID 147, MAW/6/80, Museum der Stadt Breslau); b Serpentinit (Zarzyca 6, ID 262, Museum der Stadt Breslau); c Schlammstein (Zarzyca 6, ID 176, MAW/35/81, Museum der Stadt Breslau); d Serpentinit (Janówek 1, ID 668, 1e/63, Archäologisches Institut der Universität Breslau); e Serpentinit (Janówek 1, ID 479, DA-MUWR-115/JAN, Archäologisches Institut der Universität Breslau); f Basaltoid (Janówek 1, ID 478, DA-MUWR-114/JAN, Archäologisches Institut der Universität Breslau). Vermutlich stammen einige dieser Artefakte (insbesondere a, c und f) aus der Umarbeitung von Steinwerkzeugen und nicht aus lokaler Axtproduktion, da deren Rohmaterialien nicht in der näheren Umgebung der jeweiligen Fundorte verfügbar sind. Ausgewählte Details der mineralischen Zusammensetzung provisorisch aus den Daten der energiedispersiven Röntgenspektroskopie interpretiert: Amp – Amphibol; Atg – Antigorit; Cr-Mag – Chrommagnetit; Cr-Spl – Chromspinell; Ctl – Chrysotil; Ilm – Ilmenit; Pl – Plagioklas; Px – Pyroxen; Qz – Quartz; Zrn – Zirkon.*

Probably the most interesting discovery, related to the presence of Jizerské Hory-type metabasites in Silesia, comes from the late-LBK workshop in Strzelin, Lower Silesian Voivodeship, where production debris, as well as two large adze preforms produced from this kind of raw material, were recognised (cf. Fig. 4b; see Furmanek 2019a, 67 Fig. 11). This means that not only the movement of finished stone tools but also – at least occasionally – the transportation of roughouts took place at a distance of 100 km or more. Once again, this is difficult to explain if we consider raw material acquisition strategies solely in terms of optimised production logistics. In this regard, it seems that the hypothetical possibility of a ritualised nature of journeys to quarry sites is worth considering (see Topping 2010).

Wojciechowski (2000, 86–88) suggested that »Lower Silesian amphibolites«[5] could have been involved in barter trans-

5 In fact, the Jizerské Hory-type metabasites (often referred to as »amphibolites« in the older papers) originated from Northern Bohemia and thus cannot be considered Lower Silesian raw materials.

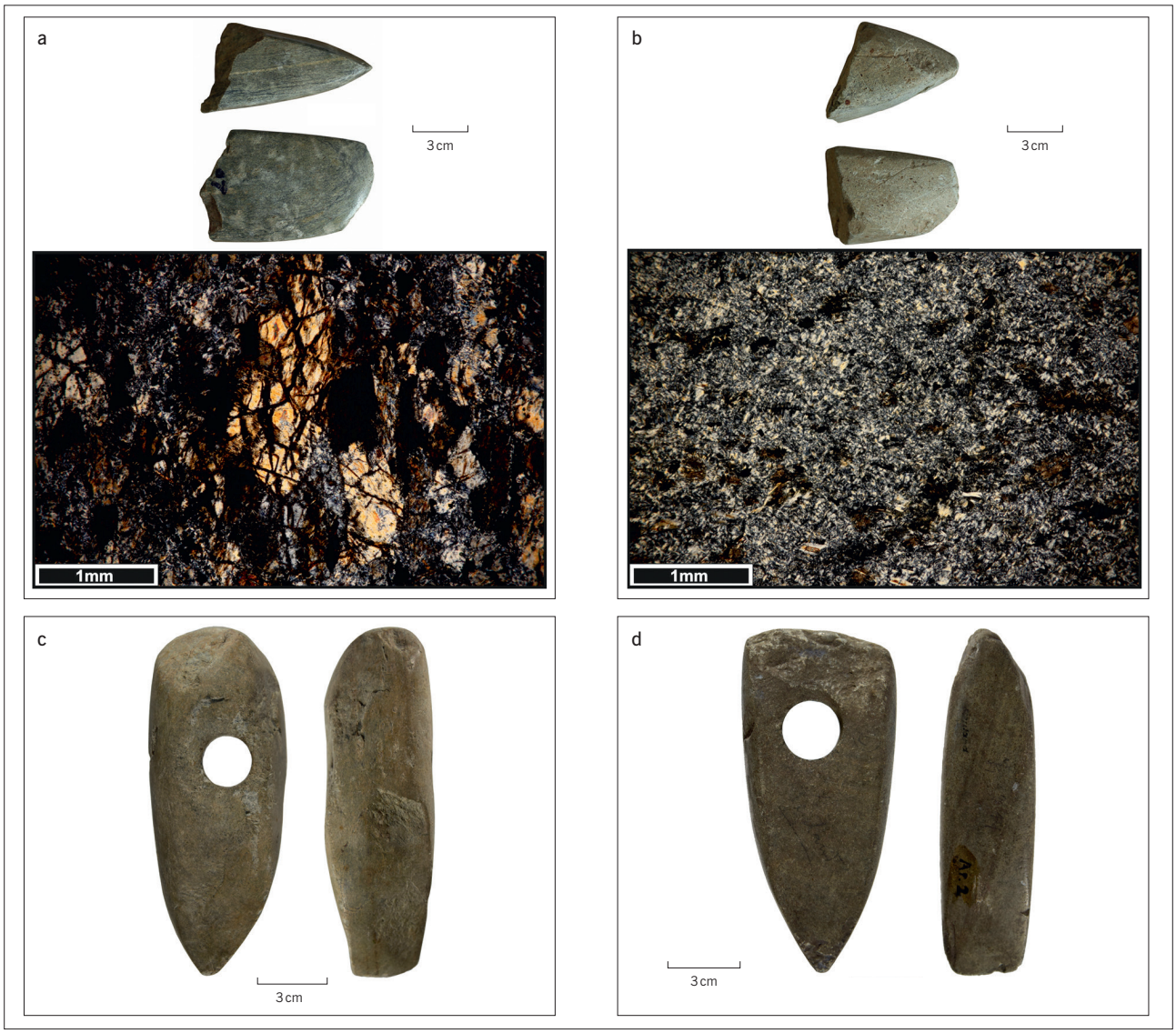

Fig. 7a–d Serpentinite shaft-hole axes of the Lengyel Culture from Lower Silesia along with associated photomicrographs of thin sections (crossed nicols): a Zarzyca 6, ID 165, City Museum in Wrocław; b Zarzyca 6, ID 166, City Museum in Wrocław; c Chociebórz, a stray find, ID 343, MNa/A/487, County Museum in Nysa; d Nysa 3 (Górna Wieś), a stray find, MNa/A/81, County Museum in Nysa.

Abb. 7a–d *Serpentinit-Schaftlochäxte der Lengyel-Kultur aus Niederschlesien mit zugehörigen Dünnschliff-Mikroaufnahmen (gekreuzte Nicol-Prismen). a Zarzyca 6, ID 165, Museum der Stadt Breslau; b Zarzyca 6, ID 166, Museum der Stadt Breslau; c Chociebórz, Einzelfund, ID 343, MNa/A/487, Kreismuseum Neisse; d Nysa 3 (Górna Wieś), Einzelfund, MNa/A/81, Kreismuseum Neisse.*

actions as an equivalent exchanged for Jurassic flint originating from Lesser Poland. Indeed, it appears possible that some of the LBK sites located in Lower Silesia might have served as redistribution centres responsible for the inflow of metabasite tools to other regional groups of this culture, in particular those inhabiting present-day Southern, Western, and Central Poland.

The STK lithic production has been relatively poorly recognised. Unfortunately, in Lower Silesia very few polished stone tools have been found that can be conclusively attributed to this taxonomic unit based on their archaeological context. It may be supposed that metabasites still constituted the dominant raw material during this period, as is also tentatively suggested for the adjacent area of Upper Silesia (Janák/Přichystal 2018, 36–38; 66).

Late Danubian Neolithic

The Late Danubian Neolithic period can be considered a time when diversification of rock types used in polished stone tool production in Lower Silesia was initiated.

Metabasites still played an important role in the lithic assortment of the Lengyel Culture, but their relative importance significantly decreased, and they can no longer be considered a dominant raw material. Moreover, a higher level of heterogeneity is observed within this lithological group. The Jizerské Hory-type is still present but often represented by small and significantly reworked artefacts (cf. Fig. 4c; Fig. 6a), so in many cases the possibility that stone tools discarded during earlier phases of the Danubian Neolithic settlement were reused must be taken into consideration. Apart from that, pol-

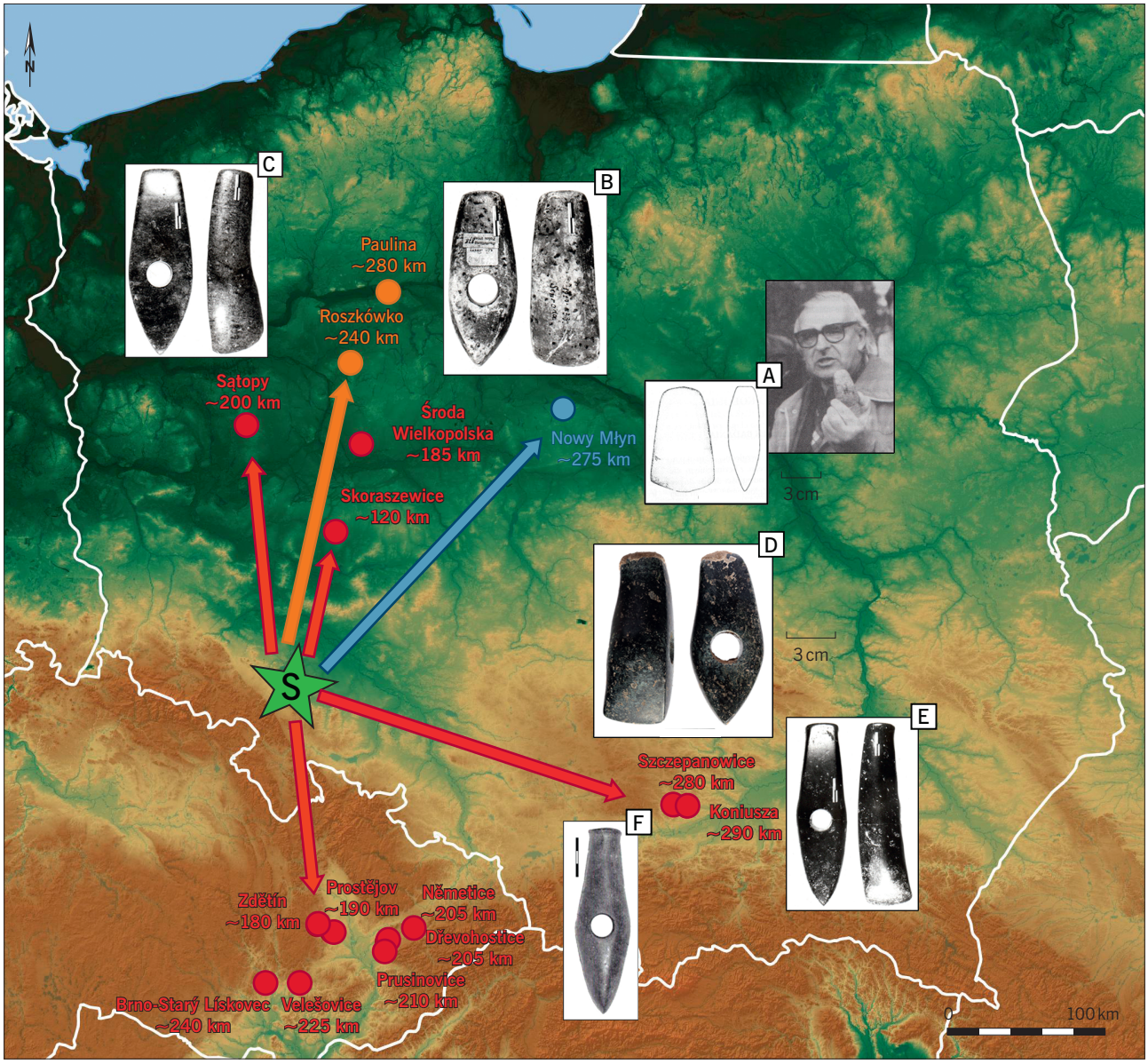

Fig. 8 Selected examples of long-distance transportation of polished stone tools produced from Lower Silesian serpentinites. The source area located in the Sudeten Foreland is roughly indicated by a green star. Findspots falling within the boundaries of Silesia have not been included. Orange dots: Late Danubian Neolithic; blue dot: Funnelbeaker Culture; red dots: Corded Ware Culture. Some representative artefacts are shown in the insets: a axe from Nowy Młyn, Kuyavian-Pomeranian Voivodeship, demonstrated in the hand of Wojciechowski (on the right, modified after Wojciechowski/Cholewa 2000, Fig. 18) and drawn (on the left, after Grygiel 2016, Fig. 305,2); b battleaxe from Środa Wielkopolska, Greater Poland Voivodeship (1910:33, Archaeological Museum in Poznań, photo by Wojciechowski); c battleaxe from Sątopy, Greater Poland Voivodeship (1894:79, Archaeological Museum in Poznań); d battleaxe from Szczepanowice, Lesser Poland Voivodeship (Institute for Archaeology and Ethnology, Polish Academy of Science in Kraków); e battleaxe from Koniusza, Lesser Poland Voivodeship (ZAK 43, Institute for Archaeology and Ethnology, Polish Academy of Science in Kraków); f battleaxe from Němetice, Vsetín district, Czech Republic (Museum Olomouc). Late Danubian Neolithic findspots after Prinke/Skoczylas 1980, Nr. 244; 1051. Findspots of CWC battleaxes from Central Poland and Lesser Poland after Majerowicz (1985, 8–10) and Wojciechowski (1988), except Szczepanowice (Dreczko et al. 2021). Findspots of CWC battleaxes from Moravia after Frýbová et al. 2018, except Němetice (Přichystal 2013).

Abb. 8 *Ausgewählte Beispiele für den Transport von geschliffenen Steinwerkzeugen aus niederschlesischem Serpentinit über große Entfernungen. Das Herkunftsgebiet im Sudetenvorland ist grob durch den grünen Stern angegeben. Fundstellen innerhalb Schlesiens fanden keine Berücksichtigung. Orangefarbene Punkte: spätdanubisches Neolithikum; blaue Punkte: Trichterbecherkultur; rote Punkte: Schnurkeramische Kultur. Einige repräsentative Artefakte sind auf den kleinen Bildern zu sehen. a Beil aus Nowy Młyn, Woiwodschaft Kujawien-Pommern, rechts in der Hand von Wojciechowski, links gezeichnet; b Streitaxt von Środa Wielkopolska, Woiwodschaft Großpolen (1910:33, Archäologisches Museum Posen); c Streitaxt aus Sątopy, Woiwodschaften Großpolen (1894:79, Archäologisches Museum Posen); d Streitaxt von Szczepanowice, Woiwodschaft Kleinpolen (Institut für Archäologie und Ethnologie, Polnische Akademie der Wissenschaften Krakau); e Streitaxt aus Koniusza, Woiwodschaft Kleinpolen (ZAK 43, Institut für Archäologie und Ethnologie, Polnische Akademie der Wissenschaften Krakau); f Streitaxt aus Němetice, Okres Wsetin, Tschechische Republik (Museum Olmütz). Fundplätze des spätdanubischen Neolithikums nach Prinke/Skoczylas 1980, Kat.-Nr. 244; 1051. Fundplätze der SK Kriegsbeile aus Zentralpolen und Kleinpolen nach Majerowicz (1985, 8–10) und Wojciechowski (1988), gilt nicht für Szczepanowice (Dreczko et al. 2021). Fundplätze der Kriegsbeile der SK aus Mähren nach Frýbová et al. 2018, gilt nicht für Němetice (Přichystal 2013).*

ished stone tools produced from a new variety referred to as the Želešice-type (cf. Fig. 4d), originating from the vicinity of Brno (cf. Fig. 2), emerged. Compared to the Jizerské Hory-type, it is usually characterised by a somehow more greenish tint in megascopic view and – most importantly – can be easily distinguished by its significantly higher magnetic susceptibility

(typically > 10 x 10-3 SI), which is due to the elevated content of magnetite. This variety was widely used for the production of axes by the Moravian Painted Ware (Lengyel) Culture (Přichystal 2013, 195–196; Trnová et al. 2024).

In addition to the utilisation of the above-mentioned non-Silesian raw materials, there was a growing interest in local lithic resources originating from the Fore-Sudetic Block, most notably serpentinites, commonly used for the production of massive shaft-hole axes (Fig. 7) typical of the LC. While these rocks are normally dark green on a freshly broken surface, exteriors of stone tools derived from archaeological contexts often show significant discolouration (pale greenish to white greyish tint). Under a polarised light microscope, serpentinites usually reveal a lepidoblastic texture and a non-pseudomorphic to partially pseudomorphic structure (cf. Fig. 7a–b). The mineral composition is typically dominated by antigorite (cf. Fig. 6b), which is often accompanied by other minerals of the serpentine group (lizardite-bastites, veins of chrysotile), carbonates, chlorite, or opaque minerals. Relics of primary ultramafic minerals (e.g., olivine, pyroxene) are usually absent.

A peculiar megascopic variety of banded serpentinite (Czech *páskovaný serpentinit,* Polish *serpentynit paskowany*), frequently recognised in the LC polished stone tool assemblages from Silesia (Janák/Přichystal 2018, 69), is characterised by a pattern of rather inconspicuous pale greenish strips on a patinated surface and often also by the presence of macroscopically observable plates of chlorite, showing typical pearly lustre. Notably, the preferred orientation of mineral constituents is hardly observable in thin sections. X-ray diffractometry reveals the presence of dominant antigorite and subordinate clinochlore. The serpentinite outcrops, where exploitation of this banded variety took place, are certainly associated with one of the Lower Silesian ultramafic bodies. However, despite the recently initiated field prospection, the precise location of the quarries remains unknown.

Another specific variety of ultramafites, identified from the LC lithic production, is a tremolite-bearing serpentinite (see Cholewa 2004, Fig. 17). This might have originated from the eastern part of the Braszowice-Brzeźnica Massif, where rocks showing similar mineral composition crop out (Gunia 1992, Fig. 3; Wojtulek et al. 2017, 151–152; 156–158 Fig. 2). However, a detailed comparative study is needed to verify the suggested provenance.

The serpentinite shaft-hole axes, attributed to the Late Danubian Neolithic based on typological criteria, are widely distributed in south-western Poland yet usually only known from stray finds (cf. Fig. 7c–d). A considerable number of these implements have been recognised from both Lower and Upper Silesia (Borowski 2019, 404–405 Fig. 8,1–3; Janák/Přichystal 2018, 39; 69 Fig. 12; Majerowicz et al. 2000, Fig. 1–9). In the opinion of Janák and Přichystal (2018, 69) this must have resulted from a relatively well-organised exchange system, possibly involving fluvial transportation

Fig. 9 Basaltoid shaft-hole axe of the Lengyel Culture (Zarzyca 6, ID 140, City Museum in Wrocław) along with associated photomicrograph of thin section (crossed nicols).

Abb. 9 *Schaftlochaxt der Lengyel-Kultur aus Basaltoid (Zarzyca 6, ID 140, Museum der Stadt Breslau) und die zugehörige Dünnschliff-Mikroaufnahme (gekreuzte Nicol-Prismen).*

of goods along the Oder River Valley. Individual serpentinite axes dated to this period are also reported from Greater Poland (Fig. 8; Prinke/Skoczylas 1980, Cat.-Nr. 244 and 1051). Nevertheless, given the scarcity of similar finds, it may be suggested that the major part of the Polish Lowlands located north of Silesia was largely outside the previously mentioned distribution network.

Two LC workshops where shaft-hole axe production took place have been recognised at the Księginice Wielkie (Czarniak 2012, 162–164 Tab. 82) and Zarzyca sites, both Lower Silesian Voivodeship, in the Sudeten Foreland. This interpretation is confirmed by the presence of tool preforms, drill cores, debris, and polishing slabs. Serpentinite was the dominant raw material used at these two locations. For example, 19 out of 22 drill cores found in Zarzyca are represented by this rock type (cf. Fig. 6b). It must be pointed out that many artefacts from this site have been macroscopically recognised as produced from the previously mentioned banded variety[6]. Interestingly, there are no potential sources of serpentinite raw material in the immediate vicinity of both sites, as they are located in a geological setting dominated by mica schists and Cenozoic rocks. The nearest outcrops of ultramafic rocks are those associated with the Gogołów-Jordanów Massif and the

6 Raw materials of the lithic assemblage from the Księginice Wielkie site have yet to be characterised. It seems likely that serpentinite artefacts from this location also include the banded variety.

7 Notably in the Szklary Massif, serpentinite tends to be strongly altered and thus should probably be considered largely unsuitable for stone tool production.

Szklary Massif[7] situated c. 10–15 km north-west and south-west, respectively (cf. Fig. 3).

Rocks outcropping in the immediate surroundings of the Zarzyca site were only occasionally used. An individual shaft-hole axe fragment was produced from olivine basaltoid (Fig. 9) most likely derived from local exposures belonging to the so-called Strzelin Volcanic Field (Awdankiewicz et al. 2016). Kowalskie and Targowica are the nearest outcrops of basaltoids, located as close as c. 2 km north and 4 km south-east of Zarzyca, respectively. The rock is almost black with scattered greenish yellow olivine grains observable on a freshly broken surface and pinkish grey on the patinated tool's exteriors.

It was most likely during the Late Danubian Neolithic period that the production of famous nephrite axes, presumably manufactured from rocks derived from Lower Silesian deposits (Přichystal 2013, 207–208), was initiated in Central Europe, as suggested by individual artefacts found in the Moravian Painted Ware Culture (LC) contexts (Přichystal et al. 2019, 297–299). According to Cholewa (2004, 40–41 Fig. 3–4), several implements produced from this raw material have also been recognised among the Danubian Neolithic stone tools from south-western Poland[8].

Clastic sedimentary rocks only sporadically occur among the Late Danubian Neolithic polished stone tools from Lower Silesia. A greywacke shaft-hole axe from Brzezie, Lower Silesian Voivodeship (Cholewa 2004, Fig. 18), which should most likely be dated to this period, could have originated from Culmian outcrops situated in the Eastern Sudetes (cf. Fig. 2). The suggested provenance is in agreement with the results of Janák and Přichystal (2018, 40), who attributed the beginnings of the exploitation of sedimentary rocks from the Nízký Jeseník Mountains to the Upper Silesian group of the LC. It should be noted that a variety of siliciclastic deposits, including Culm facies, have also been recognised from the outcrops located in Central Sudetes (i.e., the Góry Bardzkie unit and the Intra-Sudetic Basin – cf. Cholewa 2004, 40; 86–89); however, there are no indications of the prehistoric exploitation of these exposures. An individual mudstone drill core identified in Zarzyca (cf. Fig. 6c) should most likely be interpreted to have resulted from the reshaping of a tool produced elsewhere, possibly also in Upper Silesia.

Interestingly, the JC polished stone tools from the funerary assemblage found in Domasław, Lower Silesian Voivodeship, are represented exclusively by metabasites. It must be emphasised that these are large and well-preserved implements that had been intended as grave goods. Therefore, it seems that no possibility of reutilisation may be suggested in this case. Raw materials showing characteristics consistent with the Jizerské Hory-type prevail (cf. Fig. 4e); however, an individual axe representing the Želešice-type has also been recognised (cf. Fig. 4f). Notably, the latter variety has also been reported from the JC sites located in Moravia (Přichystal 2013, 196). The raw material preferences observed at the Domasław site might indicate the persistence of an old post-LBK tradition closely related to the exploitation of the long-renowned geological resources located in the Bohemian Massif. Such a practice would certainly be difficult to reconcile with the alleged largely allochthonous nature of the JC and its remote southern origin, possibly from the Carpathian Basin, as suggested by some authors (e.g., Czarniak 2012, 37–42). Nevertheless, the hypothesis presented here still needs to be verified through petrographic studies of other Lower Silesian JC lithic assemblages.

Funnelbeaker Culture

The climax of the raw material diversification in Lower Silesia should be attributed to the TRB period. A few distinctive Sudetic rocks that have been utilised for the production of polished stone tools and distributed throughout the region on a regular basis can be recognised. Apart from that, the »petrographic miscellany« observed in the TRB assemblages seems to reflect individual preferences of small-scale workshops conducting production at a household level or, in some cases, may even be the result of the release of limited numbers of similar items through one-time manufacturing. In this regard, there was also an emerging interest in the erratic rocks of Fennoscandian origin. These, however, constituted only a minor part of the polished stone tool assemblages. It may be suggested that attributes such as rarity and visual distinctiveness became increasingly important in shaping raw material choices. Interestingly, the distribution patterns seem to indicate a rather intensive intra-regional circulation of axes (and/or raw materials?) accompanied by a relatively limited extra-regional exchange. A selection of several raw materials considered particularly significant are briefly referred to below.

Serpentinite can be regarded as the most widespread Lower Silesian raw material used for the production of TRB axes (Fig. 10a–b; Fig. 11), which is largely consistent with Cholewa's results (2004, 42; 63 Fig. 5). It should be pointed out that the above-mentioned distinctive varieties of this rock, typical of the LC, have not been recognised in the TRB assemblages, which may suggest the abandonment of previously quarried outcrops. Unequivocal traces of serpentinite axe production (wastes, tool preforms, and final products) have been found at archaeological sites in Tomice and Janówek, both located in Lower Silesian Voivodeship (cf. Fig. 11; Wojciechowski 1973, 44–46; Romanow 1973, 50–52; 84–85), in close proximity to the outcrops of the eastern part of the Gogołów-Jordanów Massif (cf. Fig. 3). Notably, 4 out of 5 drill cores found in Janówek have been identified as produced from this raw material (cf. Fig. 6d–e). Similar production at a household level was also carried out at other TRB sites scattered in the surroundings of Lower Silesian ultramafic bodies, as indicated by the presence of an individual serpentinite preform in Grodziszcze, Lower Silesian Voivodeship

8 It seems, however, that the validity of the results discussed by this author should be thoroughly reassessed through the application of archaeometric methods, since the conclusions regarding nephrite axes are largely based on old raw material identification taken from the study by Geschwendt (1941). Notably, during the pre-World War II period some of the petrographers tended to qualify amphibole-rich metabasites as »nephrites« (see Klomínský et al. 2004, 63; 68; Šída/Kachlík 2009, 271 and references therein).

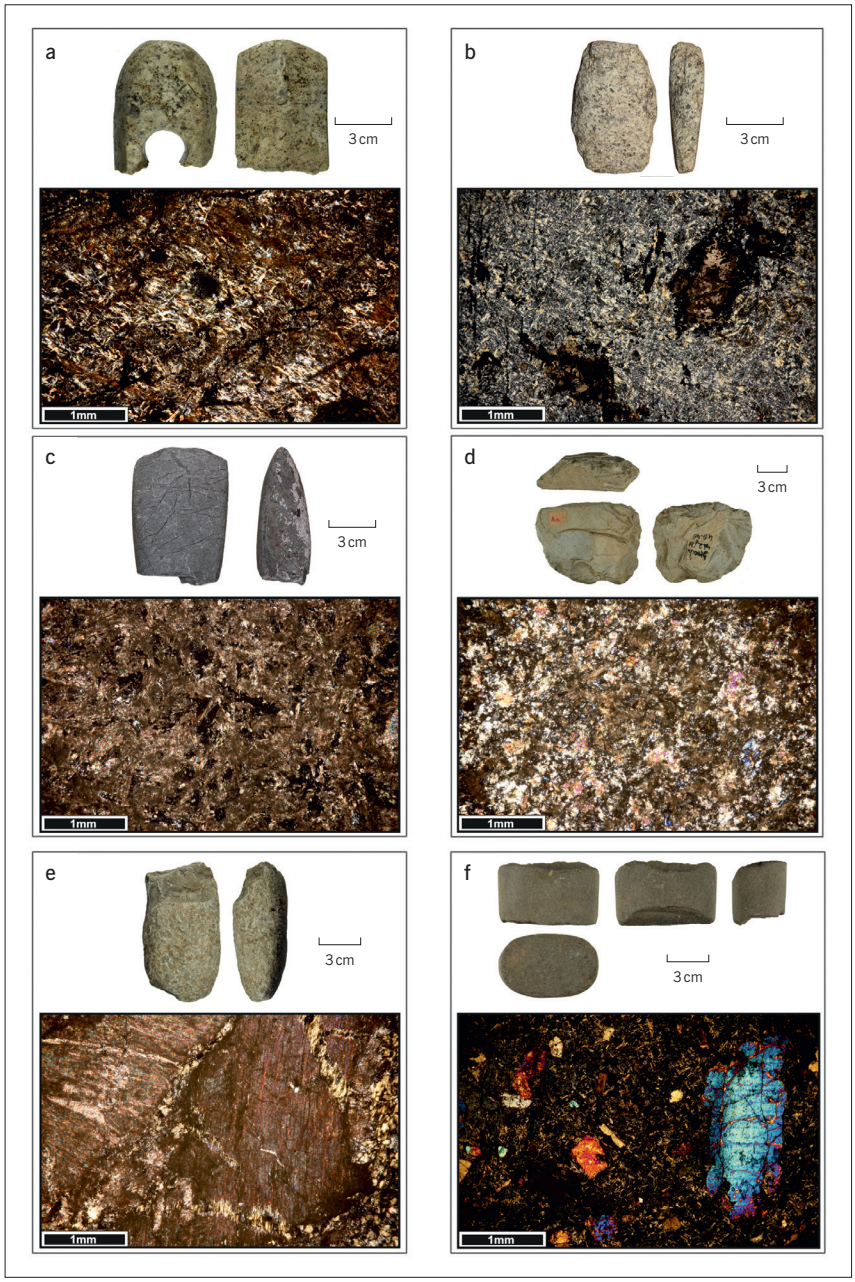

Fig. 10a–f A selection of the Funnelbeaker Culture stone tools produced from various Lower Silesian raw materials, along with associated photomicrographs of thin sections (crossed nicols): a shaft-hole axe, serpentinite (Janówek 1, ID 501, 86/62-65, Institute of Archaeology, University of Wrocław); b tool preform, serpentinite (Grodziszcze 7, ID 677, Institute of Archaeology, University of Wrocław); c axe, metadiabase (Nowa Wieś Wrocławska 4, ID 689, 34/03, Institute for Archaeology and Ethnology, Polish Academy of Science in Wrocław); d tool preform, metadiabase (Strachów 2, ID 566, Institute for Archaeology and Ethnology, Polish Academy of Science in Wrocław); e tool preform, clinopyroxenite (Strachów 2, ID 589, Institute for Archaeology and Ethnology, Polish Academy of Science in Wrocław); f axe, basaltoid (Strachów 2, ID-576, Institute for Archaeology and Ethnology, Polish Academy of Science in Wrocław).

Abb. 10a–f *Eine Auswahl von Steinwerkzeugen der Trichterbecherkultur aus unterschiedlichen Rohmaterialien aus Niederschlesien und zugehörige Dünnschliff-Mikroaufnahmen (gekreuzte Nicol-Prismen): a Schaftlochaxt, Serpentinit (Janówek 1, ID 501, 86/62-65, Archäologisches Institut der Universität Breslau); b Rohling eines Werkzeugs, Serpentinit (Grodziszcze 7, ID 677, Archäologisches Institut der Universität Breslau); c Beil, Metadiabas (Nowa Wieś Wrocławska 4, ID 689, 34/03, Institut für Archäologie und Ethnologie der Polnischen Akademie der Wissenschaften in Breslau); d Rohling eines Werkzeugs, Metadiabas (Strachów 2, ID 566, Institut für Archäologie und Ethnologie der Polnischen Akademie der Wissenschaften in Breslau); e Rohling eines Werkzeugs, Klinopyroxenit (Strachów 2, ID 589, Institut für Archäologie und Ethnologie der Polnischen Akademie der Wissenschaften in Breslau); f Beil, Basaltoid (Strachów 2, ID-576, Institut für Archäologie und Ethnologie der Polnischen Akademie der Wissenschaften in Breslau).*

(cf. Fig. 10b), several kilometres south of the western part of the same geological unit.

Wojciechowski (1983) investigated, through a targeted small-scale excavation (Fig. 12), remnants of the serpentinite quarry pits at the Jańska Góra Hill (c. 252 AMSL), situated as close as c. 2.5 km south-east of the Janówek site. Scarce archaeological materials recovered from the trench are represented by potsherds and several flint fragments. The former have been attributed to the Funnelbeaker Culture on account of their typology (cf. Fig. 12c). On this basis, a direct relationship between the quarries and the previously discovered workshops has been suggested. According to Wojciechowski (1983, 31–32), the rock was being extracted in the form of roughly rectangular blocks, which was significantly facilitated by the presence of evenly spaced parallel joints in the exploited outcrop (cf. Fig. 12g), and transported to the nearby sites for further processing. Such an interpretation is consistent with the results of the comparative petrographic study by Majerowicz (1979), which point to the eastern part of the Gogołów-Jordanów Massif as a major source area of raw materials used in TRB axe production. Recently, however, some doubts have been raised regarding the chronological position of the excavated quarry pits (Lisowska 2013, 72–75). The LiDAR imaging (cf. Fig. 12b) indicates that the spatial extent of the rock extraction area is significantly larger than previously presumed. It may be suggested that this quarry landscape, nowadays largely hidden by vegetation, should be considered »a palimpsest« that has resulted from the multi-phase serpentinite extraction, possibly spanning from prehistoric to modern times (cf. Lisowska/Gunia 2020). Therefore, it seems that the Jańska Góra site must be revisited and investigated through a large-scale excavation project in order to get a broader picture of past human activities.

It may be supposed that the circulation of serpentinite axes originating from Lower Silesia declined in the Upper

Fig. 11a–b Serpentinite tool preforms from Janówek 1, Funnelbeaker Culture: a ID 672, 12c/66, Institute of Archaeology, University of Wrocław; b ID 673, 124g/64, Institute of Archaeology, University of Wrocław.

Abb. 11a–b *Serpentinit-Rohlinge von Werkzeugen aus Janówek 1, Trichterbecherkultur. a ID 672, 12c/66, Archäologisches Institut der Universität Breslau; b ID 673, 124g/64, Archäologisches Institut der Universität Breslau.*

Oder River Basin as compared to the Late Danubian Neolithic period, since only a limited number of tools produced from this raw material have been recognised in several contexts attributed to the Upper Silesian variant of the Funnelbeaker Culture (Janák/Přichystal 2018, 40). Sporadic transportation of serpentinite tools to distant sites located in the Polish Lowlands is confirmed by an individual TRB axe found in Nowy Młyn, Kujavia, Kuyavian-Pomeranian Voivodeship (cf. Fig. 8a; Grygiel 2016, 255; Wojciechowski 2000, 87; Wojciechowski/Cholewa 2000, 90–94 Fig. 18).

Another lithological group of pan-regional importance, recently recognised in the TRB polished stone tool assemblages from Lower Silesia, are a range of light-coloured pyroxene-rich rocks tentatively qualified as significantly altered clinopyroxenites and metadiabases (cf. Fig. 10c–e). Implements produced from these raw materials show a notable heterogeneity in terms of macroscopic appearance, microstructure, and mineral composition. The rocks vary from very fine-grained to coarse-grained. The fine-grained varieties, usually resembling aplites in megascopic view, are whitish or greyish (sometimes with a slightly greenish tint) and are often crosscut by numerous veinlets (up to several millimetres thick). The coarse-grained variety is whitish with large clinopyroxene crystals (up to c. 10 mm in diameter) surrounded by irregular greenish spots. Apart from significant amounts of pyroxene (presumably diopside), rocks belonging to this lithological group contain a peculiar suite of metamorphic minerals (chlorite +/- garnet +/- vesuvianite +/- actinolite). At least some of these raw materials (in particular the coarse-grained variety) could have originated from the Braszowice-Brzeźnica Massif, where apophyses showing similar mineral composition have been recognised as partially rodingitised clinopyroxenites (Gunia 1992, 123; 128–130). At the present stage of the research, however, a range of other metagabbro-related rocks from the Fore-Sudetic Block should also be taken into account. Several lumps representing this lithological group, as well as tool preforms (cf. Fig. 10d–e) and an individual finished axe, have been found at the Strachów site, Lower Silesian Voivodeship.

Axes made of nephrite, which is often considered a prestigious raw material, are only occasionally recognised at the TRB sites. According to Cholewa (2004, Fig. 5), the frequency of nephrite among the raw materials of the overall TRB stone tool assemblage from Silesia can be estimated as several percent. However, it seems that, as is the case of similar items dated to the Late Danubian Neolithic, the validity of the archival data used by this author needs to be reassessed using archaeometric methods. The fresh surface of this rock is typically yellow-green to dark green. In thin section, nephrite reveals a nearly monomineralic composition, i.e., it is largely composed of fibrous tremolite. The famous serpentinite-hosted deposit located in the north-eastern part of the Gogołów-Jordanów Massif (in the vicinity of the Jordanów Śląski village) is considered the major source of raw material used for nephrite axe production in Central Europe (Přichystal 2013, 207–208). Apart from that, small and poorly exposed occurrences of similar rocks related to dolomitic marbles (Gil et al. 2020) are recognised to be from the vicinity of Złoty Stok, Lower Silesian Voivodeship (cf. Fig. 3), but they are usually not taken into consideration when provenance of polished stone tools is discussed.

Artefacts made of basaltoids are also relatively uncommon (cf. Fig. 6f, Fig. 10f). A small-scale exploitation of local volcanic rocks seems probable. An individual olivine basaltoid axe fragment from Strachów (cf. Fig. 10f) should most likely be considered to have been produced from a raw

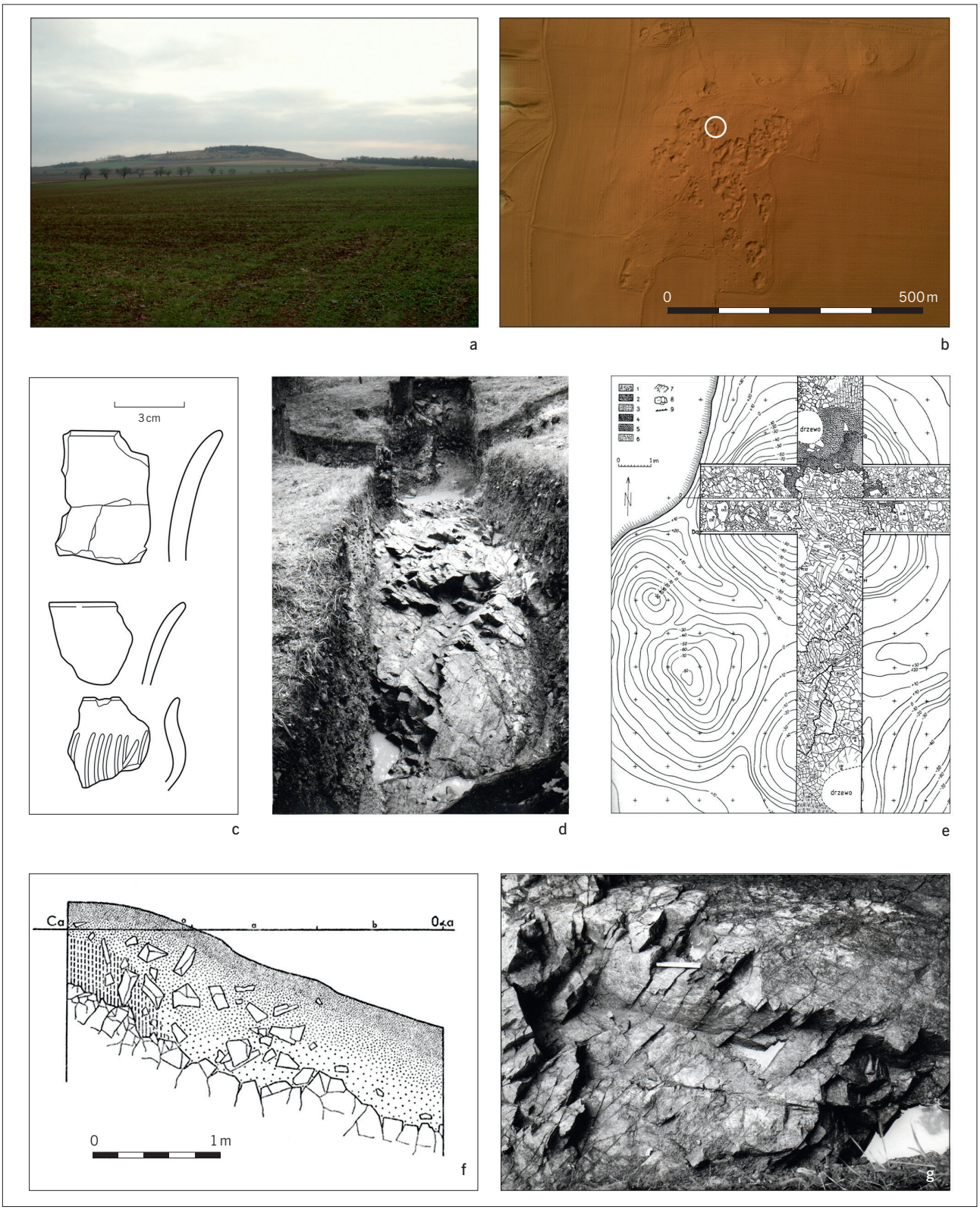

Fig. 12a–g Pictures showing a broader context and selected outcomes of the excavations conducted in the prehistoric quarrying area at the Jańska Góra under the guidance of Wojciechowski: a Jańska Góra (c. 252 AMSL), a general view from the north-west; b LiDAR image showing morphology of the extensive quarrying area in the summit part of the hill. The location of the archaeological trench is indicated by a white circle; c representative Funnel-beaker Culture potsherds recovered during the excavations; d a general view of the excavated trench; e general view of the excavated trench; f Southern cross section of a shallow serpentinite extraction pit; g detail of the quarry showing closely spaced planar fractures (joints), which could have significantly facilitated extraction of workable blocks.

Abb. 12a–g *Abbildungen, die einen breiteren Kontext und ausgewählte Ergebnisse der Ausgrabungen im prähistorischen Steinbruchgebiet am Jańska Góra unter Leitung von Wojciechowski zeigen. a Jańska Góra (ca. 252 m NHN), Gesamtansicht von Nordwesten; b LiDAR-Bild der Morphologie der großflächigen Abbauzone im Kuppenbereich des Hügels, die Lage des Grabungsschnitts ist durch den weißen Kreis angegeben; c bei der Grabung entdeckte typische Gefäßscherben der Trichterbecherkultur; d Gesamtansicht des Grabungsschnittes; e Gesamtansicht des Grabungsschnittes; f südliches Querprofil einer flachen Abbaugrube von Serpentinit; g Detail des Steinbruchs, das eng beieinander liegende flächige Brüche (Fugen) zeigt, die die Gewinnung bearbeitbarer Blöcke erheblich erleichtert hätten.*

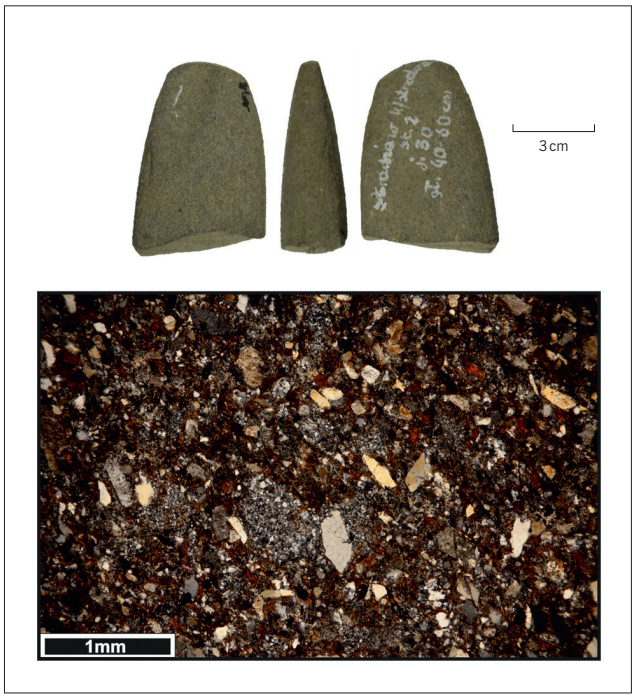

Fig. 13 Greywacke axe of the Funnelbeaker Culture (presumably produced from a Culmian sedimentary rock and transported from Upper Silesia) along with the associated photomicrograph of a thin section (crossed nicols; Strachów 2, ID 540, Institute for Archaeology and Ethnology, Polish Academy of Science in Wrocław).

***Abb. 13** Beil der Trichterbecherkultur aus Grauwacke (vermutlich aus einem kulmischen Sedimentgestein hergestellt und aus Oberschlesien transportiert) mit zugehöriger Dünnschliff-Mikroaufnahme (gekreuzte Nicol-Prismen; Strachów 2, ID 540, Institut für Archäologie und Ethnologie der Polnischen Akademie der Wissenschaften in Breslau).*

material derived from the nearby outcrops of the Strzelin Volcanic Field (several kilometres east or south-east of the site). Detailed petrographic and geochemical studies are needed to shed more light on the provenance of this kind of items. Apart from local production, the possibility of the occasional importation of basaltoid axes produced in Upper Silesia (Janák/Přichystal 2018, 54) or even significantly more distant areas (see Bartz et al. 2024 and references therein) should be taken into account. Sporadic utilisation of Fennoscandian volcanic rocks derived from local erratic resources cannot be ruled out either.

Axes made of siliciclastic rocks are only occasionally identified in Lower Silesian TRB assemblages (Fig. 13). These tools should most likely be considered to have been imported from Upper Silesia, where Culmian outcrops constituted the dominant source of raw materials used for production of TRB polished implements. A highly specialised workshop using this kind of rock was located in Holasovice, Opava district, at the northern foothills of the Nízký Jeseník, Czech Republic (cf. Fig. 2; Janák/Přichystal 2018, 46–50).

Corded Ware Culture

Famous battleaxes, widely distributed in Central Europe, should probably be considered the most spectacular element of the CWC package (Fig. 14). These implements, often found in male graves, are believed to have played a significant emblematic role; however, they obviously could have also been used as deadly weapons (Włodarczak 2017, 314).

Results of petrographic studies indicate that more than half of the CWC battleaxes found in Lower Silesia were produced from serpentinite (Cholewa 2004, 44; 69–72 Fig. 7). Based on the results of the detailed mineralogical analyses of Majerowicz (1983; Majerowicz 1985), which revealed a predominance of antigorite-rich varieties typical of the eastern part of the Gogołów Jordanów Massif, Wojciechowski (1988, 109–110) suggested outcrops located in the vicinity of the Jańska Góra Hill as a major source of raw material used by the CWC communities. However, given a variety of serpentinite structures observed in thin sections (cf. Fig. 14a–b), a slightly more cautious provenance interpretation seems reasonable.

The CWC battleaxes made of Lower Silesian serpentinite were frequently transported over large distances (cf. Fig. 8). In Wojciechowski's opinion, such a wide distribution should be attributed to the mobility of the users of these implements rather than to a well-organised exchange system. In Poland, stone tools of this kind have been found not only in the adjacent area of Upper Silesia, but also in Greater Poland (cf. Fig. 8b–c) and Lesser Poland (cf. Fig. 8d–e). Moreover, detailed petrographic studies (Frýbová et al. 2018) have confirmed the Lower Silesian origin of numerous serpentinite battleaxes found in Moravia (cf. Fig. 8).

Apart from ultramafic rocks, amphibolites and basaltoids were commonly used in the CWC battleaxe production in Lower Silesia. The amphibolites include both erratic rocks and local non-foliated varieties probably originating from the Fore-Sudetic Block. Outcrops located at the Wieżyca and Stolna Mountains in the Ślęża Massif are often pointed to as a possible source of the non-foliated amphibolites (Cholewa 2004, 44; Wojciechowski 1988, 110); however, no detailed comparative archaeometric study has been carried out so far.

Concluding remarks

Our observations are consistent with the general conclusion put forward by Cholewa (2004), who pointed to a clear predominance of rocks originating from primary resources (i.e., taken directly from outcrops) over those derived from easily available glacial boulders. This stands in contrast to the raw material procurement strategies recognised in the major part of the Polish Lowlands (e.g., Kujavia and Greater Poland), where a significant role of erratics has been demonstrated (Chachlikowski 2013; Prinke/Skoczylas 1980; Szydłowski 2017), except in the Early Neolithic assemblages dominated by metabasites. Overall, in Lower Silesia there was a strong preference for rocks obtained from mafic and ultramafic affinities, while other geological units widely-exposed in the Bohemian Massif (e.g., those comprised of granitoids) tended to be omitted in the polished stone tool production.

The preliminary results of petrographic research presented here reveal changes in raw material preferences that seem to correspond with Neolithic social dynamics in the study area. After a long period of unification characterised by the prevalence of metabasites, raw material diversifica-

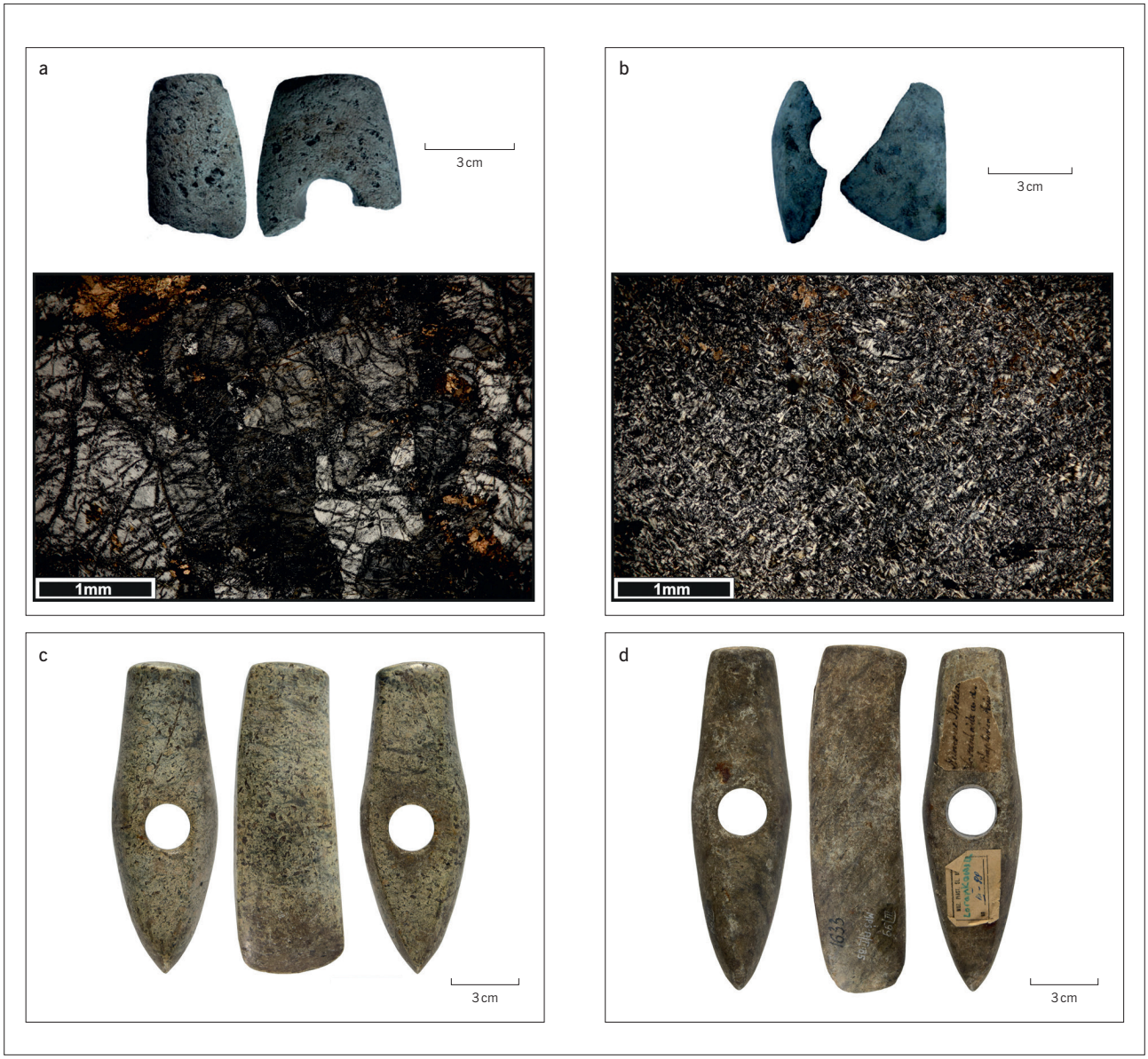

Fig. 14a–d Corded Ware Culture serpentinite battleaxes from Lower Silesia along with associated photomicrographs of thin sections (crossed nicols): a battleaxe fragment, with a well-preserved pseudomorphic structure of serpentinite (Wrocław-Widawa, Wid-8, Institute of Archaeology, University of Wrocław); b battleaxe fragment, with a non-pseudomorphic structure of serpentinite (Wrocław-Widawa, Wid-4, Institute of Archaeology, University of Wrocław); c Ślęża-type battleaxe, a stray find (undetermined location, ID 384, MPŚ A/I:24, Museum of the Silesian Piast in Brzeg); d Ślęża-type battleaxe, a stray find (Rolantowice, 8/9, ID 382, MPŚ A/I:85, Museum of the Silesian Piast in Brzeg).

Abb. 14a–d *Serpentinit-Streitäxte der Schnurkeramischen Kultur aus Niederschlesien mit den zugehörigen Dünnschliff-Mikroaufnahmen (gekreuzte Nicol-Prismen): a Fragment einer Streitaxt, mit einer gut erhaltene pseudomorphe Serpentinitstruktur (Wrocław-Widawa, Wid-8, Archäologisches Institut der Universität Breslau); b Fragment einer Streitaxt mit einer nicht pseudomorphe Serpentinitstruktur (Wrocław-Widawa, Wid-4, Archäologisches Institut der Universität Breslau); c Streitaxt vom Typ Ślęża, Einzelfund (unbekannter Fundort, ID 384, MPŚ A/I:24, Piastenmuseum in Brieg); d Streitaxt vom Typ Ślęża, Einzelfund (Rolantowice, 8/9, ID 382, MPŚ A/I:85, Piastenmuseum in Brieg).*

tion was initiated in Lower Silesia during the Late Danubian Neolithic period. A similar breakthrough, attributed to the emergence of the LC, has also been reported from Upper Silesia (Janák/Přichystal 2018, 39–40; 69) and Moravia (e.g., Trampota 2012, 447). In Lower Silesia, the highest number of rock types have been recognised in the TRB assemblages. By contrast, in the adjacent area of Upper Silesia, raw materials of the same taxonomic unit tend to be rather monotonous, i.e., dominated by Culmian rocks (Janák/Přichystal 2018, 46–50; 69–71). This discrepancy shows that changes in procurement strategies could follow different pathways, even in the neighbouring regions.

Of course, in order to comprehensively discuss associated cultural transformations and to trace the development of exchange networks, the traits observed in other artefacts must also be taken into account. In this regard, the juxtaposition with raw material acquisition strategies related to the production of grinding tools, flint implements, and ceramics may prove particularly interesting. Such a broader perspective could shed new light on interactions with the local geological environment and, more generally, changing landscape use patterns.

The petrographic characterisation of the assortments of polished stone tool raw materials will provide a good starting

point for field prospection aiming at the identification of rock outcrops exploited in the Neolithic times. Lower Silesia should be considered a very promising area for provenance studies, thanks to its diverse regional geology. Ideally, this could bring new discoveries of prehistoric quarries. It should be borne in mind that the recognition of these kinds of anthropogenic structures is significantly facilitated by recent developments in LiDAR technology and other geophysical methods of archaeological prospection. In addition to standard thin section observations, a range of cutting-edge archaeometric techniques can be used in comparative studies to trace the origin of raw materials, e.g., through geochemical signatures.

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4 Stone tool photos: Ł. Melski, M. Chłoń, Wrocław; photomicrographs: M. Borowski, Lublin

5 Modified after Borowski 2019, Fig. 5,2

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a Wojcie-chowski/Cholewa 2000, Fig. 18; Grygiel 2016, Fig. 305,2; b photo by W. Wojciechowski, Archive of the Institute of Archaeology, University of Wrocław; c photo by W. Wojciechowski, Archive of the Institute of Archaeology, University of Wrocław; d photo by M. Jórdeczka; Dreczko et al. 2021; e photo by W. Wojciechowski; Archive of the Institute of Archaeology, University of Wrocław; f Přichystal 2013, Fig. 103

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The social significance of stone axeheads in Neolithic Britain and Ireland

Alison Sheridan

Zusammenfassung

Der soziale Wert von Steinbeilen im Neolithikum Großbritanniens und Irlands

Dieser Beitrag widmet sich den unterschiedlichen, sich verändernden sozialen Rollen steinerner Dechsel- und Beilklingen im Leben der frühen Ackerbaugesellschaften in Großbritannien und Irland – von der Beschaffung und Bearbeitung des Rohmaterials über die Gestaltung und Verwendung bis hin zur Verbreitung über ausgedehnte Kontaktnetzwerke. Beleuchtet werden die kontinentalen Ursprünge frühneolithischer Beschaffungsstrategien (vor allem der Feuersteinbergbau) sowie die Niederlegungspraktiken und -ideologien. Besondere Beachtung wird der zentralen Bedeutung spezieller Beilklingen aus Jadeitit und anderem alpinen Gestein geschenkt, die von einwandernden Ackerbauern als kostbare Erbstücke (»grüne Schätze aus den fernen Zauberbergen«) mitgebracht wurden. Der Einfluss dieser alpinen Beilklingen auf die Beilproduktion in Großbritannien und Irland hinsichtlich gebirgig gelegener Rohstoffquellen und der Herstellung großer, spezieller Beilklingen soll untersucht und die charakteristische Gestaltung besprochen werden, an der man die Herkunft bestimmter Exemplare erkennen kann. Anschließend werden mittel- und spätneolithische Entwicklungen zusammengefasst, mit besonderem Augenmerk auf das Paradoxon, dass große und zahlreiche Beilklingen auf den praktisch baumlosen Shetlandinseln gefunden werden. Die Verwendung erlesener, von Spezialisten angefertigter Beil- und Dechselklingen aus Yorkshire-Flint als Machtsymbole wichtiger Männer wird erörtert und zum Schluss eine exquisite Beilklinge aus Gneis betrachtet. Sie wurde vor Kurzem in Ness of Brodgar, Orkney, als eine von mehreren Waffen (die auch als Mittel der sozialen Abgrenzung gedient hatten) gefunden und stammt aus der sozial differenzierten Gesellschaft Orkneys um 3200–2800 v. Chr.

Schlagwörter Geschliffene und polierte Steinaxtköpfe, Britannien, Irland, Neolithikum, Jadeitit

Summary

This contribution reviews the evidence for the various and changing ways in which stone axeheads (and adzeheads) played a social role in the lives of the early farming communities in Britain and Ireland – from the way in which stone for their manufacture was procured and worked, to their design and deployment, and their circulation around extensive networks of contacts. The Continental origins of Early Neolithic procurement strategies (especially flint mining), depositional practices, and ideologies are reviewed, with the key significance of special axeheads made from jadeitite and other Alpine rocks – which were brought over by immigrant farmers as treasured heirlooms, ›green treasures from the magic mountains far away‹ – being underlined. The influences of these Alpine axeheads on axehead production in Britain and Ireland, in terms of the use of mountainous sources and the manufacture of large, special-purpose axeheads, are explored. The notion of design ›signatures,‹ allowing the provenance of certain axeheads to be recognised, is discussed. Middle and Late Neolithic developments are then summarised, with the paradox of large and numerous axeheads being found in a virtually treeless Shetland being considered. The use of fine, specialist-produced axe- and adzeheads of Yorkshire flint as symbols of power of important men is then dealt with, and the paper ends by considering a very fine gneiss axehead, recently found at Ness of Brodgar in Orkney, as one of a series of weapons (which were also weapons of social exclusion) in the socially-differentiated society of Orkney, c. 3200–2800 BC.

Keywords Ground- and polished stone axeheads, Britain, Ireland, Neolithic, jadeitite

In common with the rest of Europe, in Neolithic Britain and Ireland the axe was an essential tool for farmers, being required to help clear forest for agropastoral use and – along with adzes and chisels – for the myriad woodworking tasks associated with the farming lifestyle, from building houses and other structures to making boats, containers, tools, and other artefacts. As such the axe played a key role in ensuring the smooth running and perpetuation of this lifestyle, and it is thus not surprising that museum stores are replete with ›everyday‹ utilitarian axeheads that were used for these purposes. Many are made from stone that was locally available, and some are made from non-local types of stone that were targeted for more systematic exploitation through quarrying or mining, such as the volcanic tuff of the Langdale Pikes in Cumbria, north-west England (Fig. 1; Edmonds 2012).

However, and similarly in common with elsewhere in Europe, in Neolithic Britain and Ireland many axeheads

Fig. 1 Examples of ›everyday‹ utilitarian axeheads found at Covington, South Lanarkshire (southern Scotland). These examples are of Langdale tuff and had been imported from the Lake District of north-west England, around 140 km to the south. There was large-scale axehead and adzehead production in and around the Langdale Pikes during the Early Neolithic.

Abb. 1 *Beispiele von zweckmäßigen »Alltagsbeilen« aus Covington, South Lanarkshire (Südschottland). Diese Exemplare aus Langdale-Tuff wurden aus dem etwa 140 km südlich gelegenen Lake District im Nordwesten Englands importiert. Im Frühneolithikum befand sich eine großangelegte Beil- und Dechselklingenproduktion in den und um die Langdale Pikes genannten Berge.*

had a significance over and above that pertaining to purely utilitarian or economic concerns. The circulation of axeheads over the extensive networks of contacts that the farmers established not only fulfilled the need for a reliable supply of these tools of good quality stone; it also helped to maintain the all-important social ties between communities – ties that underpinned a sense of identity and alliance, and facilitated the movement of ideas and people as well as goods. Figures 2 and 3 offer two examples of this movement, in both cases of axeheads made of Irish rock types. Figure 2 shows the five axeheads in pristine, unused condition, from a hoard of items of good quality Antrim flint that had been buried at Auchenhoan, Argyll and Bute, in west Scotland, across the North Channel from Northern Ireland (Saville 1999); while the sea-crossing was not very long (around 19 km), it required good navigational skills, as the currents are strong. Figure 3 shows a rare complete axe, found in peat at Shulishader on the Island of Lewis in the Outer Hebrides, western Scotland (Sheridan 1992). Its head is of porcellanite from Northern Ireland – either from Tievebulliagh mountain on the Antrim plateau, or from Rathlin Island, just off the coast of County Antrim – a distance of six day's sail from Lewis. Its blade is slightly asymmetrical and may have been reground; it is of a normal size for workaday axeheads. Its haft of rosaceous wood – radiocarbon-dated to 3490–2900 cal BC[1] – was finely carved. It had clearly been deposited in a watery environment, possibly a small loch. Given that this axe, with its precious, exotic head, would have been a valued possession, it may be that we are dealing with a votive deposit here, not a casual loss.

Moreover, there are numerous examples of stone axeheads that were clearly not made or used for utilitarian purposes and whose role lay wholly in the realm of ideology, belief, and inter-personal or inter-group relations. In other words, they appear to have been accorded a social function relating to notions of power (including divine power in some cases), status, wealth, and identity. Furthermore, there were aspects of targeted exploitation of axehead stone[2] that arguably reflect beliefs about the stone that are not solely related to its physical utility as a resource for making axeheads, as discussed recently by Peter Topping (Topping 2021).

This contribution summarises the evidence for socially-valued axeheads and for ideological aspects of axehead production in Britain and Ireland at various points during the Neolithic period between c. 4100 and 2800 BC (with the latter date falling a few centuries before the conventionally-defined end of the Neolithic around 2500 BC).

The Early Neolithic (c. 4100–c. 3600/3500 BC)

The widespread use of ground or polished (as opposed to flaked) stone axe- and adzeheads in Britain and Ireland is associated with the appearance of the farming way of life from around 4100 BC – a phenomenon which, thanks to the results of recent aDNA analysis, we can now confirm was due to the arrival of immigrant farming groups from

1 4470 ± 95 BP, OxA-3537: Sheridan/Saville 1993.

2 E.g., flint mining and stone quarrying on mountains and other ›liminal‹ areas.

3 Sheridan/Whittle 2023; and see that publication regarding an earlier, short-lived episode of immigration around 4350 cal BC in south-west Ireland.

Fig. 2 Axeheads (all new and unused) from a hoard of Antrim flint objects found at Auchenhoan, near Campbeltown, in south-west Scotland. These were imported across the North Channel from County Antrim in north-east Ireland. The axeheads are classic examples of the types of flint axehead produced in County Antrim using the high-quality flint available there. One has a ground blade.

Abb. 2 *Beilklingen (alle neu und unbenutzt) aus einem Hort mit Objekten aus Antrim-Flint, der bei Auchenhoan, nahe Campbeltown, im Südwesten Schottlands gefunden wurde. Sie müssen über den Nordkanal aus dem County Antrim im Nordosten Irlands importiert worden sein. Es handelt sich um klassische Beispiele für die Typen von Beilklingen, die im County Antrim mit dem dort verfügbaren hochwertigen Feuerstein hergestellt wurden. Bei einem Exemplar wurde die Schneide geschliffen.*

Fig. 3 Complete axe, with axehead of Antrim porcellanite, found at Shulishader on the Isle of Lewis, Outer Hebrides (Scotland). The axehead would have travelled a long distance by sea – a journey probably of around six days, in a small boat; haft: c. 480 mm; head: 125 mm.

Abb. 3 *Vollständiges Beil mit einer Klinge aus Antrim-Porzellanit, das bei Shulishader auf der Isle of Lewis, Äußere Hebriden (Schottland), gefunden wurde. Die Klinge muss eine lange, vermutlich etwa sechstägige Seereise in einem kleinen Boot hinter sich haben; Griff: ca. 480 mm; Kopf: 125 mm.*

various points along the north-west and northern coast of France[3]. Before then, there is only one definite example of a Mesolithic ground stone axe- or adzehead from Britain (namely an axehead found at Nab Head in south-west Wales: David 2007), although several examples are known from Ireland (Topping 2021, 11–12), including one that had been buried with cremated remains dated to 7530–7320 cal BC at The Hermitage in south-west Ireland (Little et al. 2017). This is among the earliest ground stone adzeheads in Europe, if not the earliest (Warren 2022, 1–4).

The immigrant farmers who, for various reasons, arrived in different parts of Britain and Ireland at various times between c. 4100 and c. 3800 BC brought with them their Continental practices, beliefs, and traditions concerning axe- and adzeheads. This is nowhere clearer than in the flint mines that they opened close to the southern coast of England[4], and in the axeheads of jadeitite and other Alpine rocks that they brought with them as precious community heirlooms – veritable ›green treasures from the magic mountains far away‹ (Sheridan/Pailler 2012; Sheridan et al. 2019; Pétrequin/Pétrequin in prep.). As will be argued below, the beliefs associated with these Alpine axeheads seem to have influenced aspects of Early Neolithic axehead production in Britain and Ireland.

Early Neolithic flint mining in southern England

Recent work by Jon Baczkowski (e.g., 2019a) has revealed how closely the southern English flint mines match their Continental counterparts[5] in terms of the methodologies of flint extraction and the axeheads that were produced. There had been no tradition of shaft mining in Britain prior to the opening up of the mines at Blackpatch, Cissbury, Church Hill, Harrow Hill, and Long Down in West Sussex and Martin's Clump and Easton Down in Hampshire – Britain's earliest-dated flint mines – and Baczkowski has convincingly argued that these mines can only have been opened by experienced flint miners from the near Continent, on the opposite side of the English Channel. The associated pottery from the mines (Baczkowski 2019a), and from a pit containing flint mining debitage at New Barn Down, close to Harrow Hill (Baczkowski 2022), has been attributed by Baczkowski to the Carinated Bowl tradition, which constitutes one of several regional groups of Chasséo-Michelsberg pottery (Sheridan 2007). The New Barn Down assemblage includes a very rare (for Britain and Ireland) example of a baking plate fragment (Baczkowski 2022, Fig. 4); associated dates from the pit place its use around 3960–3800 cal BC[6]. The growing radiocarbon dating evidence for the southern English flint mines has been considered by Alasdair Whittle et al. (2011, 255–62), Anne Teather (2019), Jon Baczkowski (2019a), and Kevan Edinborough et al. (2019), with several mines having a start date of c. 4000 cal BC or slightly earlier. Additional evidence confirming the production of axeheads from mined flint around this time comes from the radiocarbon date of 3960–3755 cal BC[7] on charred clematis root from the same layer as a fragment of a ground flint axehead suspected to be from the Cissbury mine, in a natural (i.e. non-mine) shaft, the Fir Tree Field shaft, on Down Farm, Dorset[8].

The opening of the southern English flint mines can be regarded as the extension of a late 5th millennium phenomenon noted in northern France, Belgium, and the Netherlands where several mines (including Jablines and Spiennes) were opened, mostly – but not exclusively – for the systematic, large-scale production of (inter alia) standardised flint axeheads at this time (Bostyn 2023; Collet/Collin 2023)[9]. It has been argued that this phenomenon was associated with a rise in population in the Paris Basin and the widespread expansion from there, from around the 43rd century BC, of farmers using Michelsberg/Chasséo-Michelsberg pottery (Pétrequin/Pétrequin 2024, 371). These farmers colonised new areas as well as other areas that had previously been farmed. The opening of the flint mines has been interpreted as a response to the consequent increased demand for axeheads (Pétrequin/Pétrequin 2024, 371).

However, it has long been acknowledged, on both sides of the Channel, that there were also social, ideological, and ceremonial aspects to this flint mining (e.g., Barber et al. 1999; Topping 2021; de Grooth et al. 2023); it would be wrong to regard it as a purely industrialised activity. While mining was undoubtedly undertaken to obtain good quality flint – and note, incidentally, that the quality of the mined flint varied, with that from the Blackpatch and Harrow Hill mines being inferior to that from Cissbury and Church Hill (Field 2023, 353) – this activity was associated with various ritual activities, probably relating to a belief that the ground (and material extracted from it) was imbued with the supernatural power of the chthonic forces therein. Mining was therefore beneficial (as it produced flint that may have been attributed divine properties) and dangerous (in a metaphysical, as well as a physical, way): the chthonic forces had to be appeased. Peter Topping has reviewed the evidence for ceremonial acts at flint mines – and rock quarries – over the course of their use-life (and beyond). These include the arguably votive deposition of items such as carved chalk objects (Topping 2021, 72–73; Teather 2016) and the so-called ›graffiti‹ marks (Topping 2021, 80). To this evidence can be added the deliberate deposition of an unused flint axehead, believed to have been produced in one of the Sussex flint mines, along with a jadeitite axehead and sherds of pottery, on inundated ground beside a wooden trackway, the Sweet Track, in Somerset (Fig. 4; Coles/Coles 1986, Pl. 28). We know, from dendrochronological dating, that this

4 Baczkowski 2019; Baczkowski 2019a; Holgate 2019; Teather 2019; Topping 2021.

5 E.g., at Spiennes, Hainaut province (Belgium), Jablines, Seine-et-Marne department (France), and Rijckhold-St Geertruid, Limburg province (Netherlands).

6 Baczkowski 2022, Fig. 3; Edinborough et al. 2019, 22; 25 Fig. 8; two modelled dates, 95 % probability.

7 OxA-8009, 5045 ± 45 BP, modelled, 89 % probability.

8 Green/Allen 2002; Whittle et al. 2011, 154–155; cf. Field 2023, 353, who cites a somewhat earlier date of 4250–3960 cal BC, OxA-7981, for a pig bone from the same layer.

9 Note, however, that, in the Netherlands, production at the mine at Rijckhold-St Geertruid appears to have been smaller in scale, and seasonal in nature: de Grooth et al. 2023.

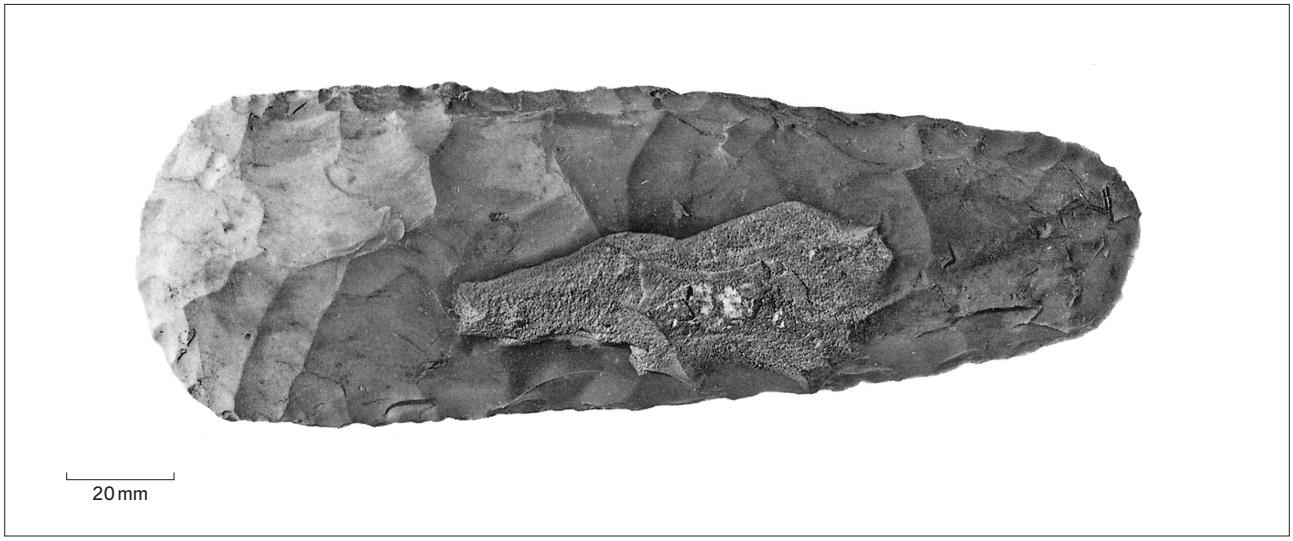

Fig. 4 Axehead of mined flint, almost certainly from one of the Sussex flint mines, found beside a wooden trackway, the Sweet Track, in Somerset, south-west England. It had been deliberately deposited there, along with a jadeitite axehead and pottery, in 3807/06 BC or shortly thereafter.

Abb. 4 *Beilklinge aus abgebautem Feuerstein, mit großer Sicherheit aus einem der Feuersteinbergwerke in Sussex, die neben einem Bohlenweg, dem Sweet Track in Somerset im Südwesten Englands, gefunden wurde. Sie war dort zusammen mit Keramik und einer Jadeitit-Beilklinge 3807/06 v. Chr. oder kurz darauf bewusst niedergelegt worden.*

trackway, around 150 km west-north-west of the Sussex flint mines, was constructed in 3807/06 BC and was used for a dozen years, and so this provides a precise date for the deposition of these artefacts. These two precious, exotic axeheads cannot represent accidental losses, but must instead have been votive offerings.

Axeheads of jadeitite and other Alpine rock types

As discussed at length elsewhere[10], the 120 or so axeheads of jadeitite and other Alpine rock types that have been found in Britain and Ireland are most likely to have arrived *not* as a result of international exchange during the 5th millennium between indigenous Mesolithic groups and Continental farmers, as some have tried to argue, without any supporting evidence (e.g., Thomas 2013, 280), but instead as treasured heirloom possessions of the farmers who migrated across the sea from various points along the north-west and north French coast from c. 4100 BC onwards. Like the aforementioned jadeitite axehead found beside the Sweet Track (Fig. 5; Pétrequin 2017, No. 2008_35), many would have been centuries old when they were brought to and deposited in Britain and Ireland (Pétrequin/Pétrequin in prep., 373; 375). Their appearance in this archipelago at the beginning of the 4th millennium BC echoes the appearance of similarly-shaped Alpine axeheads in Northern Europe, as a consequence of the expansion of the Michelsberg Culture to there (Pétrequin/Pétrequin in prep., chapter 18).

These were not workaday axeheads[11], but rather *objets-signes*, to use the French descriptor: special and, in many cases, sacred objects that may well have been believed to be imbued with the divine power of the high mountains in the north Italian Alps, from which the rock had been taken (Fig. 6). These ›green treasures from the magic mountains far away‹ – up to 1800 km away, to be precise, although their owners would have been unaware of that – could well have been associated with myths and legends that contributed to the farmers' sense of identity. Moreover, their colour, toughness, sheen, and (in some cases) edge translucency, which makes the edges appear to glow when held up to the sun (Fig. 7), could have been ascribed symbolic significance, perhaps associated with notions of strength, immortality, or apotropaic power. The practices associated with their deposition were the same in Britain and Ireland as on the Continent, with around 25 % of all examples having been found in watery contexts, as in the case of the Sweet Track axehead, and others being deposited in notable places in the landscape, such as beside a gorge (Ebbor Gorge, Somerset: Pétrequin 2017, No. 2009_0002). A few were deposited in pairs[12], and at least one had been planted upright in the ground: the example from Rattray, Perth and Kinross, in Scotland, which was deposited vertically, blade downwards, in the bank of the River Ericht (Pétrequin 2017, No. 2008_0061). Some had been deliberately ›killed‹ by breakage, burning, or both, before their deposition (Fig. 8). All these practices arguably served to remove these potent objects from the world of the living and return them to the world of the gods whence they had originated, and where they belonged, having served their purpose.

One distinctive characteristic of the British and Irish Alpine axeheads – in addition to the fact that most have been made from the finest, most luminous green jadeitite – is that a significantly higher proportion here had been pol-

10 E.g., Sheridan et al. 2011; Sheridan et al. 2019; Sheridan/Pailler 2012; Pétrequin/Pétrequin in prep., chapter 18.

11 Although they were perfectly capable of being used for felling trees and working wood.

12 Especially in Scotland, for example at Cunzierton: Pétrequin 2017, No. 2008_0056–0057.

Fig. 5a–b a The jadeitite axehead found with the flint axehead (shown in Fig. 4) beside the Sweet Track, Somerset; b *in situ*. The jadeitite originated in Monte Viso in the North Italian Alps, over 1000 km away, but the axehead was brought to England by immigrant farmers from France.

Abb. 5a–b *a Die mit der Feuerstein-Beilklinge aus Abb. 4 neben dem Sweet Track in Somerset vergesellschaftete Jadeitit-Beilklinge; b* in situ. *Der Jadeitit stammt vom Monte Viso in den norditalienischen Alpen, mehr als 1000 km entfernt. Die daraus hergestellte Klinge wurde von aus Frankreich eingewanderten Ackerbauern nach England gebracht.*

ished to a glassy sheen than on most parts of the Continent (Fig. 6). Achieving this level of sheen was a process that required skill and was very time-consuming (Pétrequin/Pétrequin in prep., chapter 12). Opinions differ on where and why this had been done[13]. Pierre Pétrequin and Anne-Marie Pétrequin (in prep., 373) have argued that it was underta-

Fig. 6 Jadeitite axehead from Greenlawdean, Greenlaw (southern Scotland). This is the eponymous axehead of ›Greenlaw‹ type, made from jadeitite from Monte Viso. It had been polished to a glassy sheen and its edges ground so smooth as to be translucent (as shown in Fig. 7).

Abb. 6 *Jadeit-Beilklinge aus Greenlawdean, Greenlaw (Südschottland). Dies ist das eponyme Exemplar des Greenlaw-Typs, hergestellt aus Jadeitit vom Monte Viso. Es wurde glasig glänzend poliert und die Kanten so glatt geschliffen, dass sie durchscheinend sind (vgl. Abb. 7).*

13 Except in the case of axeheads that had been repolished in the Morbihan region of Brittany before eventually being brought to Britain.

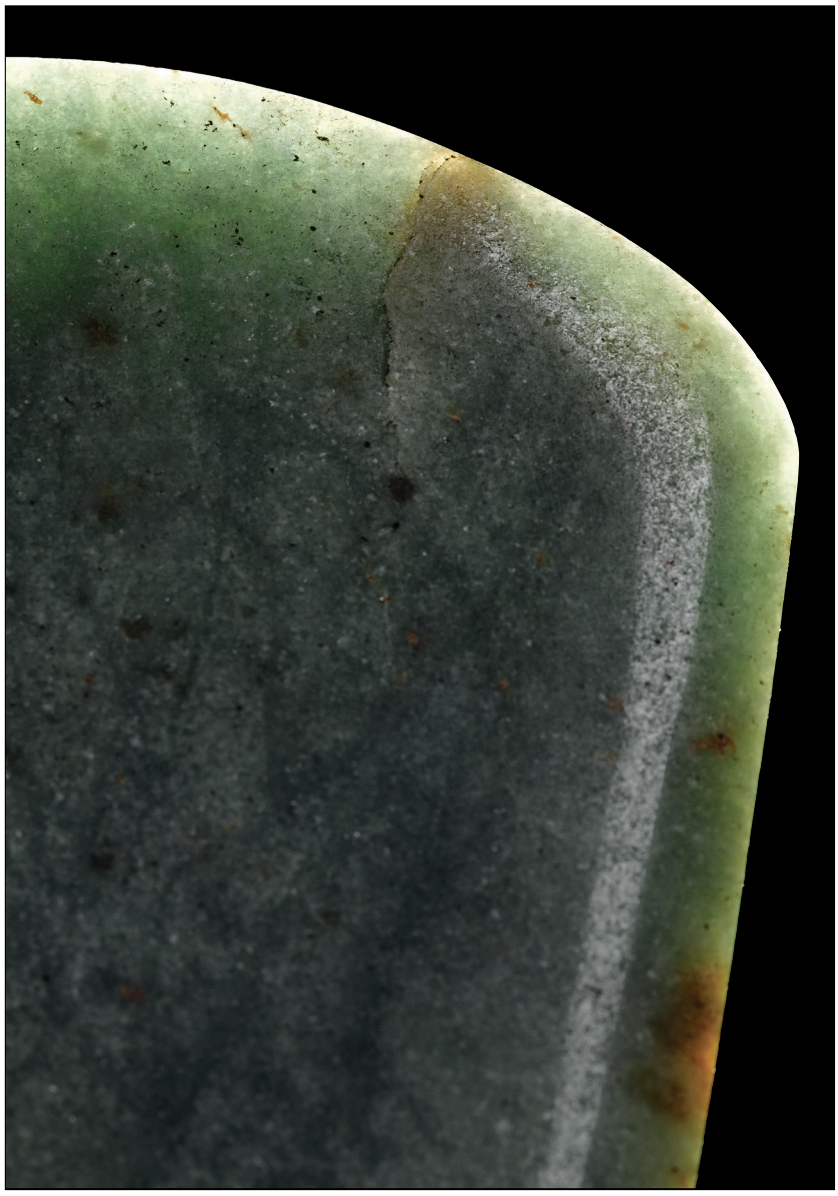

Fig. 7 Detail of the Greenlawdean jadeitite axehead showing its edge translucency when held in front of a bright light (see Fig. 6).

Abb. 7 *Detailaufnahme der Jadeitit-Beilklinge von Greenlawdean, welche die Lichtdurchlässigkeit der Kanten zeigt, wenn man sie vor eine helle Lichtquelle hält (vgl. Abb. 6).*

ken *after* the axeheads' arrival in Britain and Ireland, while the current author believes it to be more likely that this was done *before* the farmers embarked on their journey to establish a new life across the sea. If the sheen on an axehead (and indeed its thinness, allowing translucency at the edges, cf. Fig. 7) was believed to relate to the power of an axehead to protect its owner, by channelling and reflecting the sun's rays, then enhancing its sheen and translucency may have

Fig. 8 Fragment of a jadeitite axehead that had been deliberately broken and burnt before being deposited at an Early Neolithic funerary monument at Cairnholy, south-west Scotland. Note that the straight lines on the left and right sides relate to slicing of the fragment for petrological thin-sectioning several decades ago.

Abb. 8 *Fragment einer Jadeitit-Beilklinge, die intentionell zerbrochen und verbrannt wurde, bevor sie bei einem frühneolithischen Grabmonument bei Cairnholy im Südwesten Schottlands niedergelegt wurde. Man beachte, dass die geraden Linien rechts und links vom Zerschneiden des Fragments vor mehreren Jahrzehnten für petrologische Dünnschnitte stammen.*

Fig. 9 Archaeologist Jamie Quartermaine at Top Buttress, Langdale Pikes, Cumbria (north-west England). Thousands of axeheads of Langdale tuff were made in this mountainous terrain.

Abb. 9 *Der Archäologe Jamie Quartermaine am Top Buttress, Langdale Pikes, Cumbria (Nordwestengland). Tausende von Beilklingen aus Langdale-Tuff wurden in dieser Bergregion hergestellt.*

been a way of boosting its supernatural power – a property that was certainly needed for the potentially perilous sea journey. It is not known whether the thinning and repolishing was done at the points of exit (e.g., Nord-Pas-de-Calais [France]) or had already been undertaken in the Paris Basin several generations before the farmers departed for Britain, i.e., during the initial Chasséo-Michelsberg expansion out of that region from the 43rd century BC. To the current author, the consistency of the phenomenon among the British and Irish axeheads suggests that it is most likely to have been undertaken in one area, rather than in widely-scattered parts of Britain and Ireland. Since we know that there had previously been evidence for thinning and repolishing in the Paris Basin (Pétrequin/Pétrequin in prep., 297; 299 Fig. 177), and that the commonest types of Alpine axehead in Britain and Ireland – the Altenstadt/Greenlaw and Durrington types – had also been common in that region, then the Paris Basin seems the most likely candidate area for the thinning and repolishing. Whatever the case was, it appears that the farmers who came to Britain and thence to Ireland generally tended to bring with them the ›best,‹ most ›powerful‹ Alpine axeheads.

The legacy of the Alpine axeheads

The strength of the beliefs associated with the Alpine axeheads brought over by the incoming farming groups was such that it seems to have influenced both the strategies of stone exploitation by these farmers and their descendants, and the shape, size, and appearance of the axeheads that were produced.

It has long been recognised that several of the rock sources in Britain and Ireland that were exploited for axehead manufacture during the early 4th millennium BC (Edinborough et al. 2019, Fig. S10–S11) are located in mountainous areas: the Langdale Pikes in the Lake District of north-west England (e.g., Edmonds 2012), Tievebulliagh in Northern Ireland (Sheridan 1986; Mallory 1990), and Mynydd Rhiw and Graig Lwyd (Graiglwyd) in north-west Wales (Keiller et al. 1941; Houlder 1961; Burrow 2011). The arduousness of the journey up to the sources of volcanic tuff on the Langdale Pikes (Fig. 9) – the area that includes England's highest mountain, Scafell Pike (978 m) – has been eloquently described by Mark Edmonds (2012). Given that the sources of the Alpine axeheads had been in the massifs of Monte Viso and Monte Beigua, some at elevations of over 2300 m in the case of Monte Viso, it is tempting to infer that the decision to exploit the rock in the mountainous areas of Britain and Ireland had been informed by the same belief that stone taken from mountains – liminal areas between this world and that of the gods – was imbued with divine power, and therefore special. In other words, perhaps these immigrant farming groups were trying to recreate the ›magic mountains‹ scenario that had given so much significance to the Alpine axeheads. It is certainly the case that it was not essential to

Fig. 10 Example of a large, non-utilitarian axehead (called a ›Cumbrian club‹) of epidotised volcanic tuff from the Langdale Pikes in the Lake District of north-west England. This example was found in the old county of Stirlingshire, in central Scotland, around 200 km from the source area.

Abb. 10 *Beispiel einer großen, nicht nutzbaren Beilklinge (ein sogenannter Cumbrian club; dt. kumbrischer Knüppel) aus epidotisiertem vulkanischen Tuff aus den Langdale Pikes im Lake District im Nordwesten Englands. Dieses Exemplar wurde in der alten Grafschaft Stirlingshire, Zentralschottland, gefunden, etwa 200 km vom Herkunftsgebiet entfernt.*

go up mountains to find stone suitable for use in making axeheads – as is clear from the large numbers of axeheads made from rock from non-mountainous sources. It has also been noted that many Neolithic axeheads are made from stones of a green colour, and indeed the volcanic tuffs exploited on the Langdale Pikes can take a grey-green hue when ground (Fig. 10), as can some of the baked shale quarried on Mynydd Rhiw in north Wales[14]. This interest in using green (or greenish) stones could reflect beliefs about the colour green – the colour of most jadeitite axeheads (Sheridan et al. 2019).

The size and/or shape of the stone axeheads produced in Early Neolithic Britain and Ireland may also have been influenced by the Alpine axeheads. Imitation is one such expression of this influence, as in the case of two axeheads of non-Alpine rock types found in Aberdeenshire, north-east Scotland, that closely echo a Durrington-type jadeitite axehead in size and shape (Sheridan et al. 2011, Fig. 10).

The idea of making not only axeheads for everyday, utilitarian use but also ›special‹, usually outsized, axeheads is probably also a legacy of the Alpine axeheads. Among the many thousands of axeheads made from Langdale tuff are a considerable number of large (> 130 mm-long), distinctively-shaped examples, including some known as ›Cumbrian clubs‹ (Fig. 10). The overwhelming majority of these show no signs of having been used for chopping wood, and they may instead have been used as precious exchange items, tokens of wealth and status, or even as sacred objects. Their design – with its side facets and often a slight narrowing just below the butt – did not seek to copy any of the Alpine axehead shapes, but it served as a kind of ›signature‹ of the specialist producers who worked the Langdale tuff, so that anyone acquiring a ›Cumbrian club‹ would be aware of its origin. The faceted sides are also a feature of many workaday axeheads of Langdale tuff. A similar phenomenon can be seen with the differently-shaped axeheads of porcellanite that were produced in large numbers on and around Tievebulliagh mountain[15]. Here, the ›signature‹ aspect of the design of outsized axeheads (and of some workaday axeheads) was a diagonal butt, as present on the large axeheads from the Malone hoard, Belfast (Fig. 11).

A further possible legacy of Alpine axeheads is the glassy sheen seen on some large, non-utilitarian, all-over-polished axeheads of distinctive, often marbled flint (Fig. 12; Sheridan 1992; Saville 1999a; see also Moore 1979). These are slender, with (mostly) narrow side-facets and a broad, thin, convex butt; in southern England, they have been termed ›Crudwell-type‹ axeheads (Pitts 1996, 342) – although most of the southern English examples lack the glassy polish. At least 45 axeheads of this type are known from Britain[16]. Their distribution extends from Orkney to Wiltshire, and in eastern Britain it is markedly coastal (Saville 1999a, Illus. 2). Sadly, none has been found in a datable context, and the question of where they were made has not been resolved. There is an undeniable formal similarity to some Danish thin-butted axeheads of marbled flint, such as those in the Hagelbjerggård hoard, Zealand (Denmark; Nielsen 1977), which is believed to date to around the 38th century BC. However, as Alan Saville (1999b, 4–5) has pointed out, the

14 This is not the case, however, with the augite granophyre quarried on Graig Lwyd in north Wales, or the porcellanite quarried on Tievebulliagh and at Brackley on Rathlin Island, County Antrim (Northern Ireland); both are a dark blue-grey colour, and porcellanite has white, yellow, brown, and black mineral inclusions, some occurring as speckles, others as veins.

15 And also on Rathlin Island off the coast of Northern Ireland; Sheridan 1986; Mallory 1990; Cooney/Mandal 1998.

16 And note that this total excludes the five Antrim flint axeheads from the Auchenhoan hoard that Pitts wrongly attributed to this type.

Fig. 11 Hoard of large axeheads of Antrim porcellanite found in the grounds of Danesfort house, Malone Road, Belfast (Northern Ireland). These were special axeheads and show no signs of having been used; they have the ›signature‹ sloping butt, as seen on many porcellanite axeheads; no scale.

Abb. 11 *Hort mit großen Beilklingen aus Antrim-Porzellanit, der auf dem Gelände von Danesfort House, Malone Road, Belfast (Nordirland), gefunden wurde. Es waren besondere Beilklingen, die keinerlei Gebrauchsspuren, aber den charakteristischen schrägen Nacken vieler Porzellanit-Beilklingen aufweisen; o. M.*

Danish axeheads lack the glassy polish of some of the British examples, and most of the Danish thin-butted axeheads have quadrangular rather than lenticular sections, with broad facets. Saville's suggestion that Danish axeheads could have been imported to Britain and re-shaped and repolished after they arrived is unconvincing, particularly as it begs the question of where that was carried out (with the consistency of many of the British specimens arguably suggesting a single location). Moreover, his assertion that the marbled flint does not occur in Britain (Saville 1999b, 4) may not be correct, since the bed which occurs in Jutland runs under the North Sea and may extend to the east coast of England, perhaps around Lincolnshire[17]. Given the extent of coastal erosion in eastern England, it is likely that any traces of a production centre that may have existed on this coast will have been washed away. It is clear that more research needs to be undertaken on this intriguing type of axehead and on the flint from which it is made; the point to be reiterated here is that the decision to polish some examples to a glassy sheen may well have been inspired by the sheen on many jadeitite axeheads.

The Middle and Late Neolithic, from 3600/3500 to c. 2800 BC

Several developments that shed light on the social significance of axeheads during this period can be traced, with the following three being discussed here:

1. The Shetland paradox: the production of numerous and large stone axeheads, from c. 3500 BC, in a virtually treeless landscape

The Shetland Isles, a remote archipelago to the west of Norway that constitute the northernmost part of Scotland, offered particular challenges to the farmers who migrated there, probably from the west Scottish ›mainland‹, at some point during the second quarter of the 4th millennium BC (Sheridan 2014). It appears that they entered a landscape that had sparse tree cover and an unforgiving climate and, despite being able to grow barley (as attested at Jarlshof) and to keep cattle and sheep, the precariousness of their

17 Terry Manby, pers. comm.

Fig. 12 Hoard of two flint axeheads from Smerrick, Banff (north-east Scotland), measuring 183 and 251 mm in length and polished all over. Axeheads of this distinctive type have been found all along the east coast of Britain and inland, too; their date and source remain uncertain, but their glassy polish may have been inspired by that of jadeitite axeheads.

Abb. 12 *Hort mit zwei ganzflächig polierten Feuerstein-Beilklingen aus Smerrick, Banff (Nordostschottland; Länge 183 und 251 mm). Beilklingen dieses unverwechselbaren Typs wurden entlang der gesamten Ostküste Großbritanniens und auch im Landesinneren gefunden. Datierung und Herkunft sind ungewiss, aber ihre glasig polierte Oberfläche könnte von Jadeitit-Beilklingen inspiriert sein.*

Fig. 13 Large axehead of riebeckite felsite from Tingwall, Shetland (Scotland). Note the slightly expanded blade and lack of blade damage, suggesting that this had not been used to chop wood.

Abb. 13 *Große Beilklinge aus Riebeckit-Felsit aus Tingwall, Shetland (Schottland). Man beachte die leicht ausgezogene und unbeschädigte Schneide, die darauf hindeutet, dass mit diesem Exemplar kein Holz gehackt wurde.*

existence is highlighted by the evidence from a communal cist grave dating to c. 3300–2900 cal BC at Sumburgh (Montgomery et al. 2013). Here, evidence for starvation, and for the consumption of fish – a practice that had not formed part of the ›cultural baggage‹ of Britain's earliest farmers – as a way to stave off starvation, was uncovered through isotopic analysis of the human remains.

Given the paucity of trees and wood in general in Neolithic Shetland[18], it is indeed paradoxical that Shetland is well known for its numerous and large stone axeheads (up to at least 300 mm long), the vast majority of which are made of riebeckite felsite that was quarried at North Roe in the north-west part of the largest island (Cooney et al. 2019), and many of which show no obvious signs of having been used. The *North Roe Felsite Project*, led by Gabriel Cooney, University College Dublin, and Will Megarry, Queen's University Belfast, has confirmed that around 200 axeheads have been found in Shetland, and that quarrying was underway by the 35th century cal BC (Cooney et al. 2019, Fig. 4.7). Some of the felsite axeheads have a distinctive expanded blade (Fig. 13); this may constitute a design signature, analogous to that already noted for some Langdale and porcellanite axeheads. It was Roy Ritchie who first drew attention to the disjunction between the paucity of trees on Shetland and the abundance and size of the stone axeheads that were made and used there (Ritchie 1992). He contrasted the situation in Shetland, where most axeheads measure between 100 and 300 mm in length, with that in Orkney – a similarly tree-poor archipelago – where the axeheads are mostly under 100 mm long.

The abundance of axeheads extends to the domestic sphere: at Modesty, where a possibly peat-walled house had burnt down, nine axeheads were found, some heat-damaged from the burning (Fig. 14; Sheridan 2014). Even if the house had been built using some wooden elements, its occupants would not have required that many axeheads for their everyday needs. In addition to these axeheads, 13 flat ›Shetland‹ polished knives of riebeckite felsite and other rock types, some of them incomplete and some heat-damaged, were also present in the house (Fig. 15). Once again, this seems an excessive number for everyday domestic use. Two radiocarbon dates place this house in the late 4th millennium: one of 3500–3110 cal BC (SUERC-37997, 4580 ± 35 BP) from Maloideae roundwood, probably used as kindling wood (Sheridan 2014, 74), and the other of 3270–2910 cal BC[19] from burnt-on organic residue from the interior of a sherd.

As with axeheads, large numbers of ›Shetland‹ knives have been found in Shetland; one hoard, found on Stourbrough Hill, contained 19, all unused, some bleached to a light colour from having lain in peat (Fig. 16). The grinding and polishing of these knives had brought out the beauty of the porphyritic and spherulitic riebeckite felsite (along with gabbro [?], pegmatite [?], and an unidentified rock) that had been selected for their manufacture. Many of the felsite axeheads are also visually striking. Much time and effort went into the manufacture of both these artefact types.

How can this superabundance of axeheads (and knives) be explained? The interpretation that seems most plausible to the current author is that these artefacts acted as tokens of value, to be amassed as wealth and probably also

18 With driftwood from North America providing a welcome addition to the limited local supplies.

19 UBA-40573, 4405 ± 31 BP: Sheridan et al. 2019a, 228.

Fig. 14 Axeheads of riebeckite felsite from a burnt-down Neolithic house at Modesty, Shetland (Scotland). Some show heat damage. Blade damage is minimal or non-existent, suggesting that these had probably not been used for chopping wood.

Abb. 14 *Beilklingen aus Riebeckit-Felsit aus einem niedergebrannten neolithischen Haus bei Modesty, Shetland (Schottland). Einige Exemplare weisen Hitzeschäden auf. Die Schneiden sind minimal oder gar nicht beschädigt, was dafürspricht, dass sie wahrscheinlich nicht zum Holzhacken verwendet wurden.*

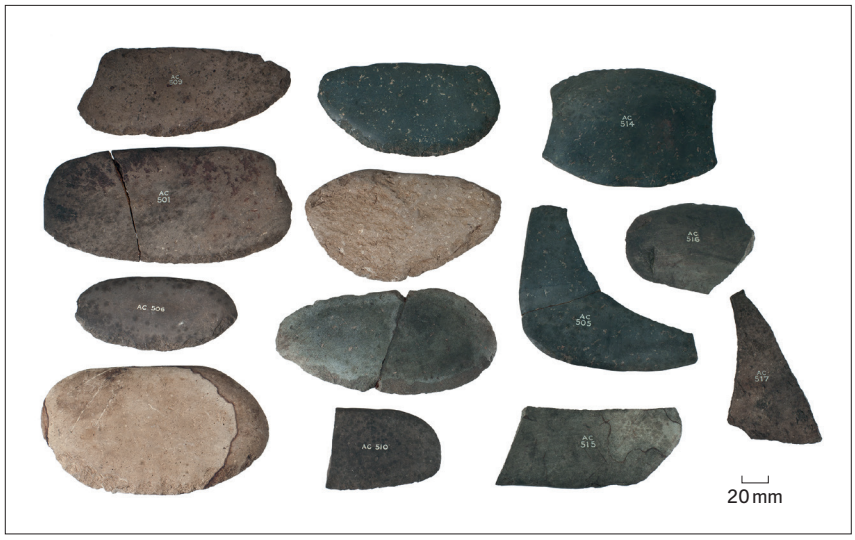

Fig. 15 ›Shetland knives‹ of riebeckite felsite and andesite (?) from a burnt-down Neolithic house at Modesty, Shetland (Scotland). Some show heat damage; several are incomplete and could have been broken by the burning and collapse of the house. Petrological identifications by Mik Markham.

Abb. 15 *»Shetland-Messer« aus Riebeckit-Felsit und Andesit (?) aus einem niedergebrannten neolithischen Haus bei Modesty, Shetland (Schottland). Einige Exemplare weisen Hitzeschäden auf; mehrere sind unvollständig und könnten durch den Brand und den Einsturz des Hauses zerbrochen sein. Petrologische Bestimmung durch Mik Markham.*

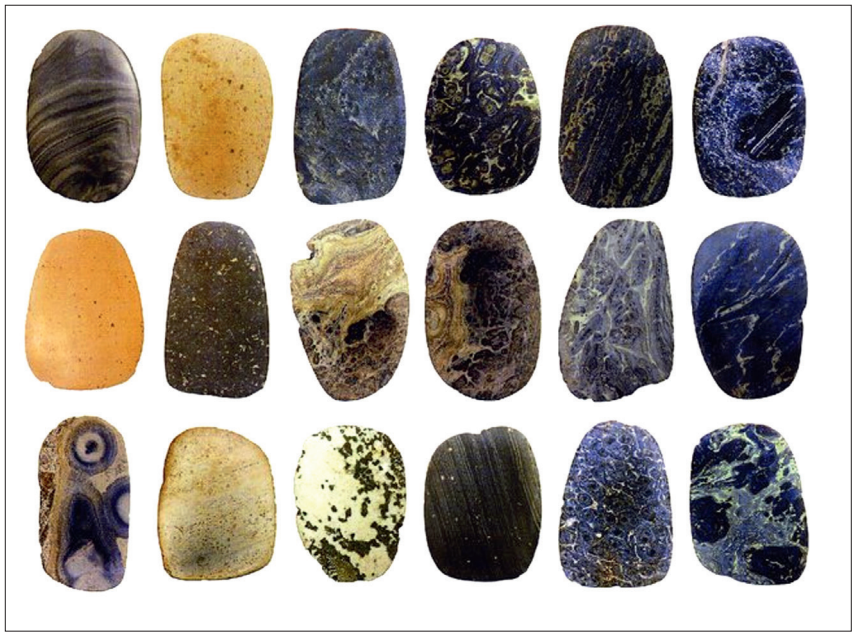

Fig. 16 Eighteen of the 19 seemingly unused ›Shetland knives‹ found as a hoard on Stourbrough Hill, Shetland (Scotland). Most are of riebeckite felsite; others are of gabbro, pegmatite, and an unidentified stone. Petrological identifications by Mik Markham; each around 150 x 100 mm.

Abb. 16 *Achtzehn der 19 anscheinend unbenutzten »Shetland-Messer«, die als Hort auf dem Stourbrough Hill, Shetland (Schottland), gefunden wurden. Die meisten sind aus Riebeckit-Felsit, andere aus Gabbro, Pegmatit und einer unidentifizierten Gesteinsart. Petrologische Bestimmung durch Mik Markham; jedes etwa 150 x 100 mm.*

Fig. 17 ›Seamer axehead‹ (dimensions 115 × 32 × 14 mm) and jet belt slider from grave of adult male at Whitegrounds, East Riding of Yorkshire (north-east England). These edge-ground axeheads were made by specialist flint-workers on the Yorkshire Wolds and would have been valued personal possessions, symbols of power of important men in the community. Typically, this ›Seamer axehead‹ shows no signs of having been used for chopping wood.

Abb. 17 *Beilklinge vom Typ Seamer (115 × 32 × 14 mm) und Gürtelschlaufe aus Gagat aus dem Grab eines männlichen Erwachsenen aus Whitegrounds, East Riding of Yorkshire (Nordostengland). Solche Beilklingen mit geschliffener Schneide wurden von spezialisierten Feuersteinbearbeitern aus den Yorkshire Wolds hergestellt und müssen wertvoller persönlicher Besitz sowie Machtsymbole wichtiger Männer der Gemeinschaft gewesen sein. Bezeichnenderweise gibt es an der Beilklinge keine Anzeichen dafür, dass sie zum Holzhacken verwendet wurde.*

exchanged between communities on special occasions (e.g., as bridewealth). Some axeheads were indeed doubtless used for chopping wood (and perhaps other materials), and some knives were doubtless used for skinning and butchery, but arguably the principal function of Shetland axeheads and knives was as a kind of social ›glue‹ connecting communities that needed to stay in contact to support each other, and perhaps allowing people to compete with each other in terms of how many they could amass.

2. The emergence of specialist flint-working on the Yorkshire Wolds, north-east England, and the deposition of fine flint axe- and adzeheads in high status male graves and hoards

In 1995, Tess Durden reported on the skilled, specialist production of a range of artefacts, including distinctively-shaped, waisted axe- and adzeheads – so-called ›Seamer axes‹ and ›Duggleby adzes‹ – on the Wolds (high ground) of Yorkshire in north-east England. These artefacts were made of locally-available nodular flint from the glacial boulder clay deposits, readily available on the coastal beaches below (Durden 1995). Thanks to a programme of radiocarbon dating at the Duggleby Howe funerary monument (after which ›Duggleby adzes‹ are named: Gibson/Bayliss 2009), along with other dating evidence (discussed in Sheridan 2012), we can now say that these waisted blades were in use between c. 3350 and c. 2900 cal BC, and probably towards the earlier end of that date range[20]. These axe- and adzeheads, mostly over 75 mm long and with expanded thin butts and rounded blades, are finely flaked and mostly ground or polished only over the blade and lower part of their body (Fig. 17–18), although a recently-discovered example from Sandbach in Cheshire East (Fig. 19), around 180 km from the Yorkshire production areas, has been ground smooth all over its body. Where these items have been polished, in some cases it has been to a glassy sheen. The flint selected to make them is often brightly coloured – red, yellow, orange (as in the case of the Sandbach example) – or mottled (Manby 1979, 69). The distinctiveness of the shape of these objects constitutes the same kind of ›signature‹ as that noted above for some Early Neolithic axeheads of Langdale tuff and Antrim porcellanite. Moreover, ironically, there are a few examples where Langdale tuff has been used to make copies of these Yorkshire objects[21]. The fact that a rough-out for one such example has been found at Keighley, West Yorkshire (Manby 1979, Fig. 3.1), suggests that the specialist

20 The radiocarbon dates from human bone associated with the eponymous ›Duggleby adze‹ in Grave G at Duggleby Howe have been Bayesian-modelled at *3345–3210 cal BC*, 94 % probability: Gibson/Bayliss 2009, Tab. 1.

21 E.g., Barrow 32, Willerby Wold, East Riding of Yorkshire: Manby 1979, Fig. 5.6; Drumlithie in north-east Scotland: Kenworthy 1981, 191; and Freugh, Stoneykirk, south-west Scotland, on display in the National Museum of Scotland, NMS X.AF 322.

Fig. 18 ›Duggleby adzehead‹ (236 mm long) and crown antler macehead associated (along with a lozenge-shaped arrowhead) with an elderly adult male skeleton in Grave G, Duggleby Howe, North Yorkshire (north-east England). Comments about its manufacture, significance, and condition are as per the ›Seamer axehead‹ from Whitegrounds in Fig. 17.

Abb. 18 *Dechselklinge vom Typ Duggleby (236 mm lang) und Keulenkopf aus einer Geweihsprosse, die (zusammen mit einer rautenförmigen Pfeilspitze) aus Grab G, Duggleby Howe, North Yorkshire (Nordostengland), eines älteren männlichen Erwachsenen stammen. Herstellung, Bedeutung und Zustand wie bei der Beilklinge vom Typ Seamer aus Whitegrounds in Abb. 17.*

stone-workers in Yorkshire acquired Langdale tuff as blocks of raw material and worked it in Yorkshire.

The distribution of these ›Seamer‹ axeheads and ›Duggleby‹ adzeheads is extensive, with several examples known from Scotland, and others cited by Kenworthy from southern and eastern England, including the River Thames (Kenworthy 1981), although there is a clear concentration of finds in Yorkshire and Lincolnshire (Fig. 20). The creation of an overall distribution map, along with a critical review of all claimed specimens, is overdue. Some have been found in hoards, most notably a large hoard found in York that includes other products of the specialist flint-working ›industry‹ of the Wolds (Fig. 21; Clarke et al. 1985, 252–253). At least four have been found in funerary contexts – in individual graves, some associated with round mounds – and, where the human remains have survived and been sexed, they are invariably male. A particularly fine example is known from Whitegrounds round barrow, East Riding of Yorkshire (Fig. 17), where a ›Seamer‹ axehead had originally been placed at the lower back of a contracted male skeleton,

Fig. 19 ›Duggleby adzehead‹ (measuring 136 × 51 × 16 mm and polished all over) of orange-brown flint probably from the glacial till of the Yorkshire coast, found at Sandbach, Cheshire East (north-west England). Normally this kind of adzehead is ground only over the blade end of the body. Typically of ›Duggleby adzeheads,‹ this shows no sign of having been used to chop wood. It would have been a precious personal possession, a male symbol of power.

Abb. 19 *Ganzflächig polierte Dechselklinge vom Typ Duggleby (136 × 51 × 16 mm) aus orange-braunem Feuerstein, der vermutlich von den eiszeitlichen Ablagerungen an der Küste von Yorkshire stammt. Gefunden wurde er bei Sandbach, Cheshire East (Nordwestengland). Normalerweise ist diese Art von Dechselklinge lediglich am Schneidenende geschliffen. Es gibt keine Anzeichen, dass dieses Exemplar zum Holzhacken verwendet wurde, was typisch für Dechselklingen vom Typ Duggleby ist. Sie muss einst ein wertvoller persönlicher Besitz gewesen sein, ein männliches Machtsymbol.*

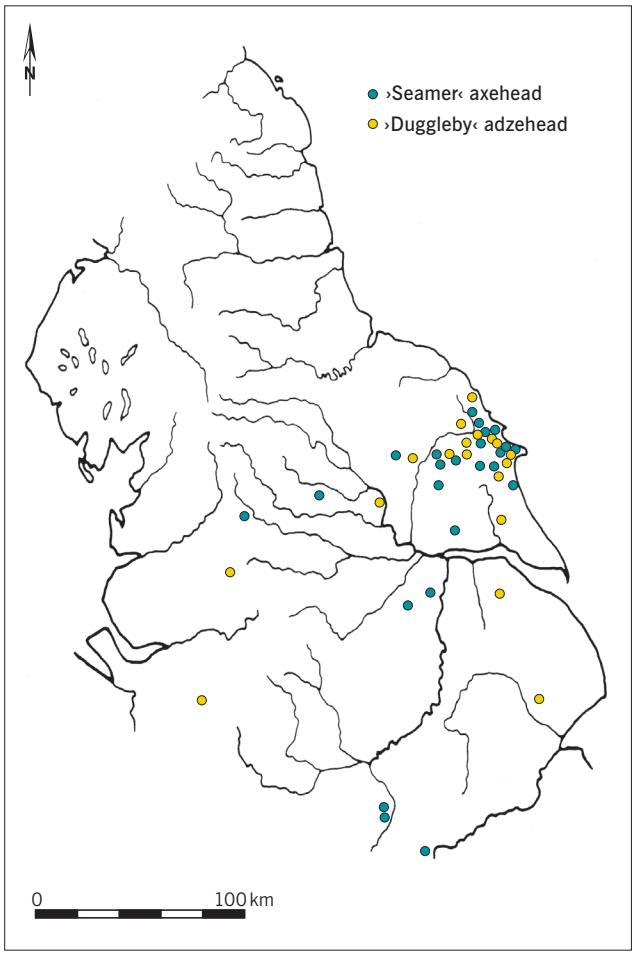

Fig. 20 Distribution of ›Seamer axeheads‹ and ›Duggleby adzeheads‹ from Manby 1974, with the findspot of the Sandbach ›Duggleby adzehead‹ added. A few further examples of these specialised artefact types have been found elsewhere in Britain.

Abb. 20 *Verbreitung der Beilklingen vom Typ Seamer und der Dechselklingen vom Typ Duggleby nach Manby 1974. Die Fundstelle der Duggleby-Dechselklinge bei Sandbach wurde ergänzt. Weitere Exemplare dieser speziellen Artefakttypen wurden an anderen Stellen in Großbritannien gefunden.*

beside a jet belt ›slider‹ – another precious and prestigious possession – that had probably been attached to a belt (Brewster 1992; Manby et al. 2003, Fig. 20). The skeleton has been radiocarbon-dated to 3510–2920 cal BC[22]. This grave had been dug into the top of a pre-existing Neolithic round mound. At Duggleby Howe, where the eponymous adzehead was found, it was associated with the contracted skeleton of a mature adult male, aged around 60 years, and was accompanied by an antler macehead and a large, fine lozenge-shaped flint arrowhead (Fig. 18); as with the jet belt slider at Whitegrounds, these artefacts would have constituted status symbols (Gibson/Bayliss 2009; Kinnes 1979, Fig. 18.8). The interment was one of a series of secondary depositions in a pit associated with a round barrow; isotopic analysis indicated that this man, like others buried at Duggleby Howe, had not been raised in the area (Montgomery et al. 2007). Two graves containing these distinctively-shaped axe- and adzeheads are known from southern Scotland, although sadly no human remains have survived. A ›Seamer‹ axehead was found, along with a leaf-shaped bifacial object of the kind known from the specialist flint-working sites of the Yorkshire Wolds, in a pit dug into an Early Neolithic long barrow at Biggar Common, South Lanarkshire (Fig. 22,1: Sheridan 1992, 206–207); and at Knappers, in Dunbartonshire, a ›Duggleby‹ adzehead was found in a boulder-built cist with a large capstone (Fig. 22,2: Kenworthy 1981). One of the end stones has pecked motifs, including two concentric circles (Ritchie/Adamson 1981, Pl. 9b). A further possibly funerary find is from Ayton East Field, Seamer Moor, North Yorkshire, where a ›Seamer‹-like axehead was found along with two other flint axeheads, an edge-polished adzehead, five lozenge-shaped flint arrowheads, two flint knives (one polished), two ›spearheads‹, flakes, a sandstone rubber, two boar-tusk blades, and an antler macehead (Kinnes 1979, 127; Fig. 18.5). These artefacts had been deposited at the top of a round mound, along with bones that may be human. At all the findspots listed above, there is no unequivocal evidence that the axe- and adzeheads had been used to chop wood; they are in fairly pristine condition.

All this evidence indicates the deployment of these distinctive axe- and adzeheads to signal the high status of a small number of people, almost certainly all men. However, ›Seamer‹ axeheads were not the only kind of specialist-produced, high-quality edge-ground/polished axehead to have been produced by the Yorkshire specialist flint-workers towards the end of the 4th millennium, as already seen with the York hoard (Fig. 21) and Ayton East Field assemblage. For example, long, tapering axeheads with gently pointed butts – of Terence Manby's ›Class D3c‹ (Manby 1979, Fig. 4.3) – have been found in graves at Bessingby, East Riding of Yorkshire (namely a stone-lined pit containing a human skull: Earnshaw 1973; Manby 1979, 80) and at Liff's Low, Derbyshire, some 150 km south-west of the Yorkshire Wolds (Fig. 23; Loveday/Barclay 2010). The Liff's Low grave was an ›open-topped octagonal cist‹ under a round mound, and it contained the slightly contracted skeleton of a young adult male, with an antler macehead behind his knees and a set of other precious objects behind his head: a ›D3c‹ flint axehead, a shorter, broader edge-polished flint axehead, two long kite-shaped flint arrowheads, two lozenge-shaped ›spearheads‹, two edge-polished flint knives, one serrated; numerous other pieces of flint, three pieces of red ochre, two boar's tusks, and a unique ceramic container decorated in the style of Middle Neolithic ›Peterborough Ware‹ pottery (Loveday/Barclay 2010, 108). The number and range of grave goods make this the richest-equipped Neolithic single grave in Britain. The skeleton has been radiocarbon-dated to 3360–3090 cal BC[23]; the results of strontium and oxygen isotopic analysis of his tooth enamel and bone do not suggest that he had been raised far from the area where he was buried (Jay et al. 2019, 497–498; Appendix 1; Tab. 1).

22 95.4 % probability; 3370–3090 cal BC at 68.2 % probability: Har-5587, 4520 ± 90 BP.

23 SUERC-26173, 4510 ± 30 BP: Loveday/Barclay 2010, 128.

Fig. 21 Selection of objects from a large hoard of specialist-produced Yorkshire flint artefacts including a ›Duggleby adzehead‹ (166 mm long), axeheads, knife, blades, flake, scrapers, and preforms for scrapers/›spearheads‹. Most appear to be unused. Found at York, in a pit, 1.8–2.1 m below the surface, in 1868.

Abb. 21 *Auswahl von Objekten aus einem großen Hortfund mit von Spezialisten angefertigten Artefakten aus Yorkshire-Flint einschließlich einer Dechselklinge vom Typ Duggleby (166 mm lang), Beilklingen, eines Messers, Klingen, eines Abschlags, Schabern und Vorformlingen von Schabern/»Speerspitzen«. Die meisten scheinen unbenutzt zu sein. Gefunden 1868 in einer Grube in York, 1,8–2,1 m unter der Oberfläche.*

One further find of a finely-made, edge-polished axehead of Yorkshire flint resembling Manby's ›D3c‹ type merits discussion, because of the distance it had travelled and the uncertainty as to its date. This is the axehead found, along with a necklace comprising 12 chunky ›monster beads‹ – all but one definitely of jet – and four beads of amber, at Greenbrae,

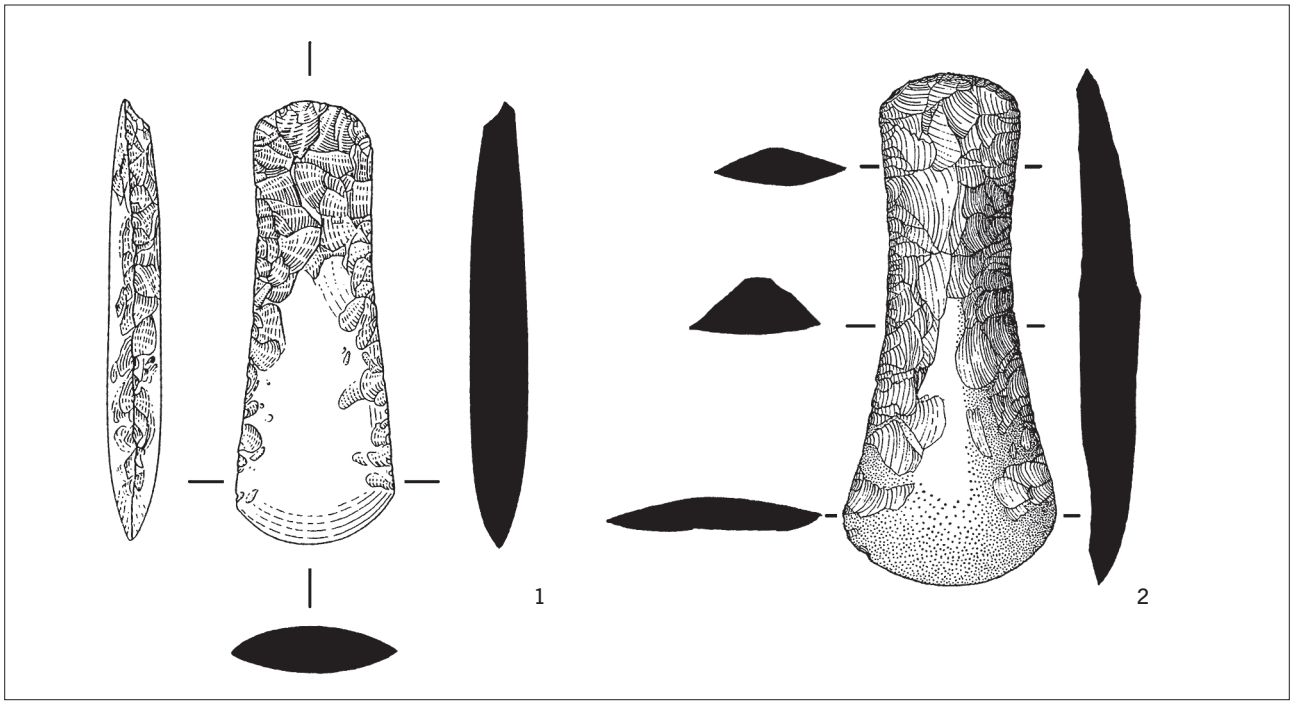

Fig. 22 1 ›Seamer axehead‹ (118 × 41 × 16 mm) from grave at Biggar Common, South Lanarkshire; 2 ›Duggleby adzehead‹ (134 × 54 × 17 mm) from a grave at Knappers, Dunbartonshire (both southern Scotland). These were long-distance imports from Yorkshire in north-east England.

Abb. 22 *1 Beilklinge vom Typ Seamer (118 × 41 × 16 mm) aus einem Grab bei Biggar Common, South Lanarkshire; 2 Dechselklinge vom Typ Duggleby (134 × 54 × 17 mm) aus einem Grab bei Knappers, Dunbartonshire (beide Südschottland). Diese sind Fernimporte aus Yorkshire im Nordosten Englands.*

Fig. 23 Two fine edge-ground axeheads of Yorkshire flint, along with a crown antler macehead, a boar's tusk, two pieces of red ochre, and a unique pottery vessel, from among the grave goods from an individual adult male grave at Liff's Low, Derbyshire (northern England); length of longest axehead 188 mm.

Abb. 23 *Zwei hochwertige Beilklingen mit geschliffener Schneide aus Yorkshire-Flint und ein Keulenkopf aus einer Geweihsprosse, ein Eberzahn, zwei Stückchen roter Ocker und ein einzigartiges Keramikgefäß, die sich unter den Beigaben eines männlichen Erwachsenen in einem Einzelgrab bei Liff's Low, Derbyshire (Nordengland), fanden; Länge des längsten Axtkopfes 188 mm.*

Aberdeenshire, on the north-east coast of Scotland (Fig. 24; Kenworthy 1977). This was an old find (1812), and original reports are sketchy and contradictory; according to some (Kenworthy 1977, 85), it was associated with some kind of mound. It is unclear whether the objects had been buried as a hoard or in a grave, although the latter is a possibility. What is clear, however, is that Yorkshire is the most likely area of origin of both the necklace and the axehead, since: 1. the only significant source of workable jet in Britain occurs on the coast around Whitby (and as far north as the Cleveland coast), and inland at the western end of the North York Moors; 2. amber is known to occur on the north-east English coast but is only rarely found on the coast as far north as Aberdeenshire; 3. as noted above, the axehead – edge-polished and tapering to a narrow, thin butt – shares some features in common with Manby's ›Class D3c‹ axeheads, which are well represented in Yorkshire (Manby 1979, 68–69; Fig. 4.3); and 4. in Scotland, flint does not occur in nodules of sufficient size to make the 163 mm-long Greenbrae axehead. It would appear, therefore, that the Greenbrae axehead and its associated necklace constituted a precious and prestigious import to Scotland, symbols of power of an important person, that had travelled c. 335 km northwards along the coast.

The dating of the Greenbrae assemblage is problematic, however. On the one hand, if the axehead genuinely is of ›D3c‹ type, then, by analogy with the dated Liff's Low example, it should date to within the last 350 years of the 4th millennium. On the other hand, its association with ›monster beads‹ suggests that it could be as old as c. 3600/3500 BC, by analogy with dated examples of such beads in Britain (Sheridan 2007a; Sheridan 2009). One such bead (not of jet), found at Flixton in Suffolk, was associated with a Mildenhall bowl, which is estimated to date between the 38th and 35th centuries BC (Sheridan 2009). However, as discussed elsewhere (Sheridan 2007a), the dating of this bead type leaves a lot to be desired. Nevertheless, the Greenbrae find raises the possibility that, in Yorkshire, specialist flint axehead production, with some long-distance exports, could have been occurring prior to the late 4th-millennium *floruit*. The question of the northwards exporting of Yorkshire flint to Scotland has been discussed by Torben Ballin (2011).

3. Axehead manufacture as part of a range of specialist stone artefact production to make symbols of power in Late Neolithic Orkney, within the 3200–2800 BC bracket: creating objects that were both weapons for combat and weapons of social exclusion

In Orkney, the period between c. 3200 and c. 2800 BC saw the emergence and flourishing of a remarkable social phenomenon, in which a new ›world order‹ appears to have been established by an ambitious, dynamic, and innovative group of prosperous cattle farmers, as part of a long-standing rivalry between different groups in Orkney. Space does not permit a detailed discussion of this phenomenon here – see Sheridan (2024) and Card et al. (2020) for recent discussions – but, essentially, this period saw the construction of Maeshowe passage tomb, as a direct result of members of the Orcadian elite having visited the massive passage tomb of Newgrange in the Boyne Valley in Ireland, and the adoption and adaptation of the sacred designs that were pecked into the stones at Newgrange. It also saw the construction of a new, open-air type of monument – the stone circle within a henge at the Stones of Stenness – and of other stone settings; the construction of nucleated settlements, for example at Barnhouse and Skara Brae; the invention of a new, flat-based type of pottery, Grooved Ware, and the manu-

Fig. 24 Edge-ground flint axehead (163 × 55 × 26 mm) and associated necklace of ›monster beads‹ of jet and jet-like material and amber beads, all imported from Yorkshire, found at Greenbrae, Aberdeenshire (north-east Scotland). These would have been precious and prestigious possessions.

Abb. 24 *Feuerstein-Beilklinge mit geschliffener Schneide (163 × 55 × 26 mm), vergesellschaftete Kette mit »Monsterperlen« aus Gagat und einem gagat-artigen Material sowie Bernsteinperlen, alle aus Yorkshire importiert und bei Greenbrae, Aberdeenshire (Nordostschottland), gefunden. Es muss sich um wertvolle und prestigeträchtige Besitztümer gehandelt haben.*

facture of chunky, ostentatious jewellery made of materials including sperm whale ivory and whalebone. The novelties also included the development of the remarkable site at Ness of Brodgar, close to the Stones of Stenness and Maeshowe (Card et al. 2020). With its increasingly large, piered stone buildings, this may well have been a place where important visitors from far and wide, drawn by the fame of the monuments in this area, could be accommodated as they undertook their ›pilgrimage‹. Some of the cattle that were eaten at feasts here were remarkably large, having been bred by mating domesticated cattle with aurochsen (probably on the northern ›mainland‹ of Scotland) to maximise meat yield per animal.

Distinctively-shaped carved stone objects are a prominent aspect of the material culture of this period in Orkney, and they were made in a variety of shapes – smooth and knobbed stone balls, spiked objects, one object that resembles a hand grenade, pillow-shaped stones, and a variety of maceheads[24]. Some were made at Ness of Brodgar, and some maceheads featured in ceremonies where they were deliberately broken. A recent addition to the repertoire is the pristine double-bladed, chisel-like ›axehead‹ from Ness of Brodgar that is shown, along with a carved stone ball, an unfinished pestle macehead, and a broken cushion macehead from Ness of Brodgar, in Fig. 25. Like many of the other Orcadian carved stone objects, it has been made of visually striking rock – a black and white gneiss, in this case. At nearly 160 mm long, it is significantly longer than the small, ›workaday‹ axeheads of Neolithic Orkney (Ritchie 1992) and, in this author's opinion, it was probably designed as a status symbol and a weapon, rather than as a tool for felling trees or working wood. Indeed, all of the distinctively-shaped carved stone tools belonging to this period in Orkney could well have been designed as prestigious weapons: items that could maim or kill. That some had indeed been used as such is evident, for instance, from the evidence for blunt-force trauma seen on skulls from Cuween passage tomb, with the diameter of the injuries being consistent with the size of a macehead or carved stone ball. However, as symbols of power, these objects were also weapons of social exclusion: possession of these precious objects would have been restricted to the elite. It is in this context that the fine gneiss axehead from Ness of Brodgar is to be understood.

24 For images of many of these objects, see <https://www.orkneystonetools.org.uk/about> (27.06.2024) and Card et al. 2020, chapters 18– 19.

Fig. 25 Double-bladed narrow ›axehead‹ (nearly 160 mm long), along with a carved stone ball, an unfinished pestle macehead, and a broken cushion macehead, all from Ness of Brodgar, Orkney. These were precious and prestigious symbols of power, designed to be both weapons and weapons of social exclusion. The axehead was not designed for use in chopping wood.

Abb. 25 *Schmale »Beilklinge« mit zwei Schneiden (fast 160 mm lang), ein* carved stone ball *(zur Kugelform geklopfter und geschliffener Stein), ein unfertiger stößelförmiger Keulenkopf und ein zerbrochener kissenförmiger Keulenkopf, alle aus Ness of Brodgar, Orkney. Es muss sich dabei um wertvolle und prestigeträchtige Machtsymbole gehandelt haben, die sowohl als Waffen als auch der sozialen Ausgrenzung dienten. Die Beilklinge war so gestaltet, dass sie nicht zum Holzhacken gedacht gewesen sein kann.*

Conclusions

This review of the evidence for the social significance of axeheads (and adzeheads) in Neolithic Britain and Ireland has highlighted the varied and changing ways in which they could serve a purpose over and above (or other than) that of a tool for felling trees and chopping wood. From the precious, sacred, magical green treasures from the distant Alps that pioneering farmers brought with them from France shortly after 4000 BC to the exquisite but deadly weapon from Ness of Brodgar, these objects clearly have much to tell us about the beliefs and preoccupations of the people who made and owned them.

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Axes along the Seine Valley: From the mine to the grave

François Giligny

Zusammenfassung

Die Beile des Seine-Tals: von der Mine bis zum Grab

Als Teil einer umfangreichen Studie zum historischen Verlauf des Neolithikums im Seine-Tal (von Paris bis zur Mündung) wurde die Beilherstellung in einem fünfzehnjährigen Forschungsprojekt untersucht. Die Produktion vor Ort wurde mit den importierten Beilen aus dem Armorikanischen Massiv, den Alpen und anderen Gebieten verglichen. Dank der lokalen Produktionsstätten (Bergwerke und Werkstätten) können die Arbeitsschritte der örtlichen Beilherstellung für jedes der Rohmaterialien (Feuerstein aus dem Bartonium und aus der Kreidezeit sowie Sandstein/Quarzit) und die Unterschiede zu den importierten Beilen beschrieben werden. Anhand der Überprüfung der Rohlinge und der geschliffenen Beile aus der Oberflächenprospektion und der Kartierung dieser Funde lässt sich die Verteilung der Beile während der unterschiedlichen Herstellungsschritte untersuchen. Die Ausweitung der Studie auf den westlichen Teil des Pariser Beckens macht es möglich, den Tauschhandel über weite Entfernungen und den Status der größten Stücke zu erörtern, die als Prestigeobjekte galten.

Unserer Meinung nach spielte eine gesellschaftliche Elite bei der Kontrolle des Umlaufs dieser Waren eine Rolle und zentrale Orte, wie beispielsweise große Rondelle und monumentale Grabanlagen, waren die territorialen Marker dieser Sozialstruktur.

Schlagwörter Neolithikum, Feuersteinbeile, Bergwerke, *chaînes opératoires,* soziale Unterschiede

Summary

Research concerning axe production in the Seine Valley, from Paris to the estuary, was undertaken over a period of 15 years. It is one of the topics of the largest programme studying the Neolithic historical trajectory in this area. The local production was compared to the axes imported from the Armorican Massif, the Alps, or other areas. The local production sites (mines and workshops) make it possible to describe the chaîne opératoire *of local axe production for each raw material (Bartonian flint, Cretaceous flint, sandstone/quartzite) and to differentiate them from imported ones. The review of the roughout and polished axes from the surface survey and the cartography of these discoveries offer insight into the study of the distribution of the axes at different stages of production. Enlarging the programme to the western part of the Paris Basin, it is now possible to discuss the long-distance exchanges and the status of the largest examples, which are considered prestige goods.*

We propose that an elite class of the society must have played a role in controlling the circulation of these goods and that central places, such as large enclosures and monumental graves, were the territorial signs of this social structure.

Keywords Neolithic, flint axes, mines, *chaînes opératoires,* social differences

Introduction

The Paris Basin is a region rich in siliceous resources, especially flint. From the centre (Tertiary basin) to its periphery (Secondary basin), it is characterised by a diversity and abundance of materials (Giligny 2011; Bostyn et al. 2018). Over a period of fifteen years, in collaboration with local research institutions and stakeholders, we conducted a research programme on the production and circulation of flint and rock axes in the west of the Ille-de-France, in an area of the Seine Valley between the cities of Paris and Rouen (Fig. 1).

This area is located at the fringes of the centre of the Paris Basin, where the Cretaceous outcrops are limited to valleys and to some depressions (synclinal/anticlinal). Here, a great diversity and abundance of materials can be found (Fig. 2): Secondary flint (Senonian, Campanian), Tertiary (Bartonian) flint, and sandstone (quartzite sandstone). All these materials were worked during the Neolithic in axe mines or workshops and are represented at both the Secondary and Tertiary geological levels.

Our research project consisted in identifying and analysing local and exogenous axes found through prospecting and excavation, which are now housed in 16 public or private collections. The research has led us to build a database of 2936 flint axes (Fig. 3) and about 1230 pieces of tenacious and solid rocks. We also focused our field work on the archaeological prospecting of production sites, such as the Flins-sur-Seine/Aubergenville, Dép. Yvelines (Île-de-France), mining site, where flint mining is known exclusively through surface collections since the 1930s. This work has now been published (Giligny/Bostyn 2016), and we propose to use the results to illustrate the theme of the conference.

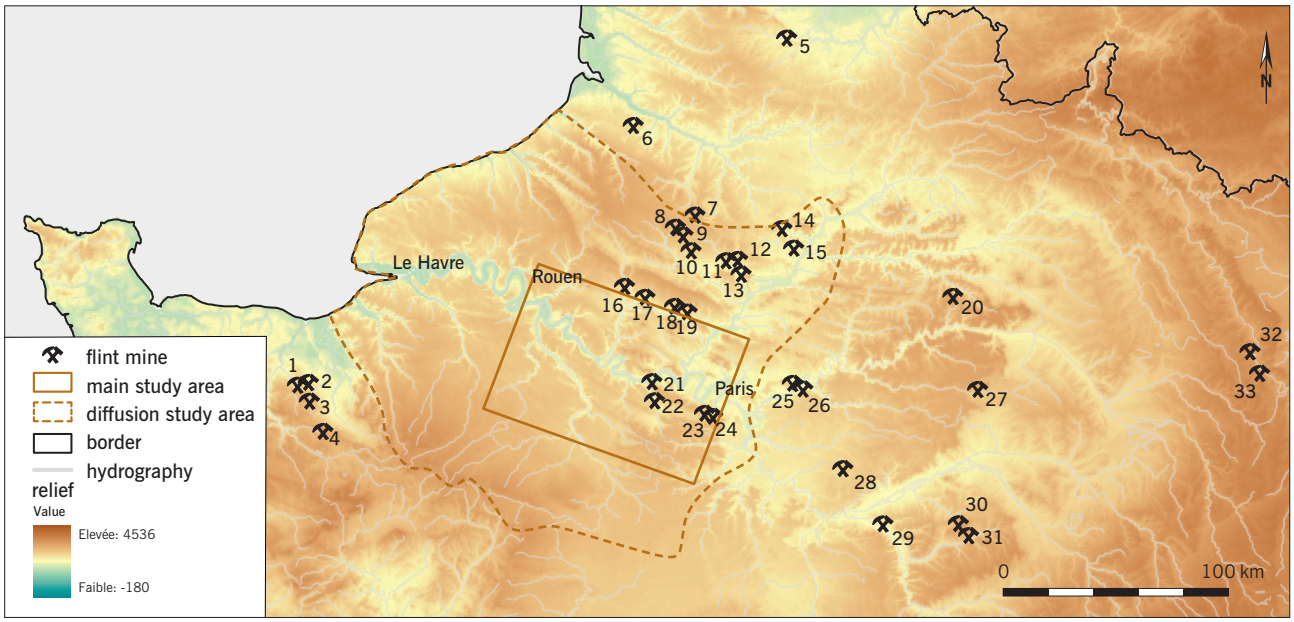

Fig. 1 Study area and distribution of flint mines in northern France and Belgium.

Abb. 1 *Untersuchungsgebiet und Verbreitung von Feuersteinbergwerken in Nordfrankreich und Belgien.*

1. Bretteville-le-Rabet; 2. Soignolles; 3. Potigny; 4. Ri Rônai »Le Fresne«; 5. Fampoux-près-Arras; 6. Hallencourt «Les Bouts du Mont»; 7. Hardivillers »Les Plantis»; 8. Auchy-la-Montagne; 9. Luchy; 10. Velennes; 11. Airion; 12. Lamecourt «Route de Cuignières»; 13. Nointel «Bois du Chêne Auger»; 14. Ressons-sur-Matz »Le fond Madelon Duriez«; 15. Coudun; 16. Sérifontaine »Champignolles« ; 17. Jaméricourt; 18. Saint-Crépin-aux-Bois/Ibouvilliers; 19. Méru »Carrière Brébant«; 20. Rhomigny-Lhéry; 21. Flins-sur-Seine »Le Clos«/Aubergenville; 22. Maule »Moussets«; 23. Sèvres »Le Brimborion«; 24. Meudon »Bas-Meudon«; 25. Jablines »Le Haut Château«; 26. Coupvray »Les Chauds Soleils«/Bouleurs ,27. Coizard-Joches »La Haie Jeanneton« ; 28. Nangis; 29. Serbonnes »Le Revers de Brossard«; 30. Pâlis »le Buisson Gendre«; 31. Villemaur-sur-Vanne »Le Grand Bois Marot« & »Les Orlets«; 32. Saint-Mihiel »Côte de Bar«; 33. Commercy »Côte de Bucy«.

The main goals of the project, which aimed to characterise the socio-economic role of axe productions for Neolithic societies, was based on the following questions:

- Which was the axe production context: How many people were involved in the community? Was there a specialisation of extraction and production, an apprenticeship?
- Was there a regional specialisation (e.g., mining complex) focused on axe production and controlling resources or trade?

The research protocol has followed several main steps (Giligny/Bostyn 2016). The first one was the identification of production sites (mines, workshops) and the description of the production processes for each local material (flint from the Tertiary and Secondary geological contexts). We intended, within production sites, to identify the degree of specialisation by studying the waste products.

We also analysed the axe consumption modes and their contexts (settlements, graves, deposits) as well as the diffusion of local products at a regional scale; additionally, and more broadly, we identified some products at an interregional scale at a distance of more than 150 km to the north and west.

The distribution of exogeneous axes helped us to define the role of the Seine Valley in long distance exchange networks, the Seine Valley being a major axis of circulation and exchange during the Neolithic, especially for exotic jade axes from the Alps.

In our conclusion, we try to define socio-economic territories and their structuration.

The collections were documented – a large part of this work was performed by students in the framework of a master's or PhD thesis – and a representative selection of axes was described in a database (with some 3D models). We are preparing an online option for this database at the HumaNum repository portal[1]. Flint axe collections bring together all stages of the *chaîne opératoire* because most of them come from mines or workshops. A majority of the Tertiary flint axes are unpolished (the artefacts extending from nodule or plate, prepared with only unifacial or bifacial knapping, to roughout and axe) as are almost one third of the Secondary flint axes. Some were reused (as hammers or wood-splitting wedges) or transformed into other tools (see Fig. 3).

Chronological frame

The first Neolithic sites in the Seine Valley are dated to the Villeneuve-Saint-Germain Culture or VSG (5000–4700 BC), which followed the latest phase of the Linear Pottery or »Rubané du Bassin Parisien« (Fig. 4). Dense occupation clusters assigned to this culture are known in the Seine Valley and on the silt or loess plateaus (Bostyn et al. 2009). One isolated Linear Pottery site is known further west in the Caen plain, and it is possible that yet unknown settlements

1 <https://www.huma-num.fr/> (07.06.2024).

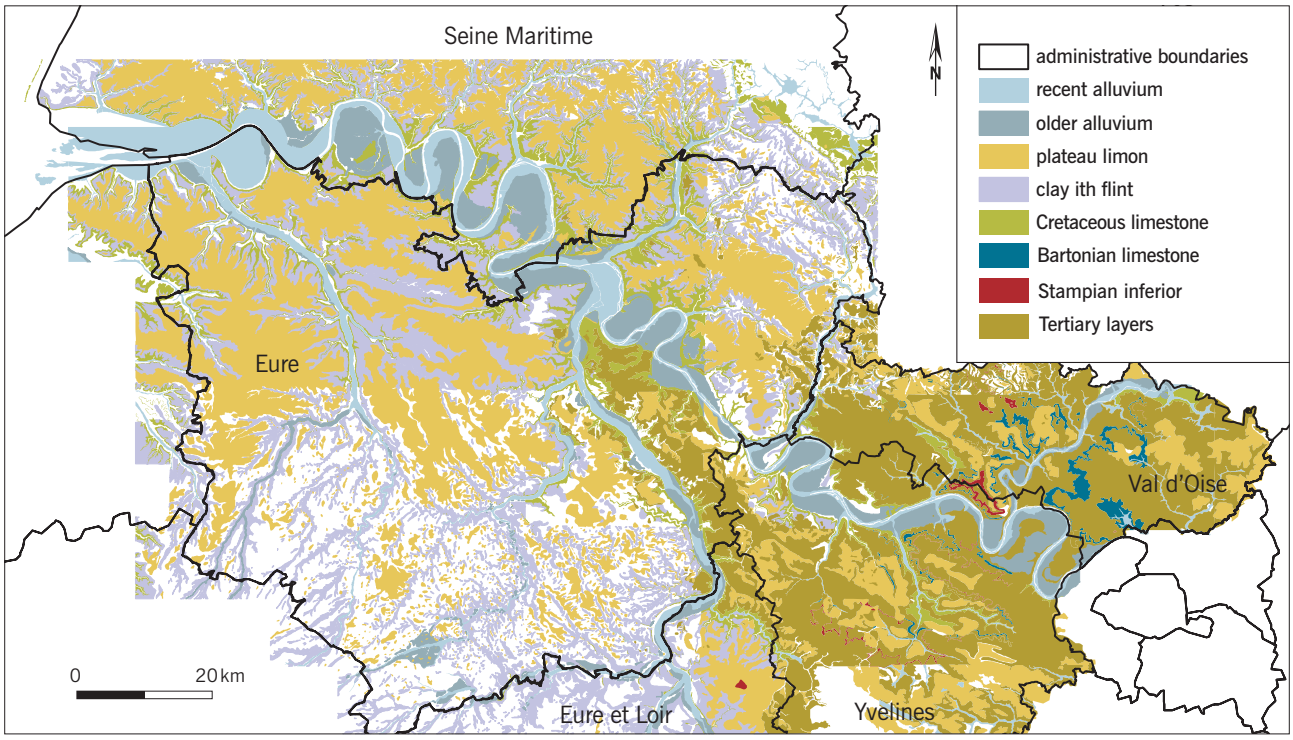

Fig. 2 Geological context.

Abb. 2 *Geologischer Kontext.*

dated to the Linear Pottery Culture may have existed along the Seine River between Paris and Rouen.

Flint mines in the Paris Basin have been exploited from the Middle Neolithic period onwards (4700–3400 BC). An important phenomenon of such Neolithic societies is the emergence of enclosures and monumental burials during the Cerny, Rössen and Post-Rössen, and Chasséen or Michelsberg Cultures. During the Late Neolithic (Seine-Oise-Marne: 3400–2800 BC) and the Final Neolithic (Gord and Bell Beaker: 2800–2200 BC), numerous collective burials were established and then reused. Axes are found very often in these graves. Single burials reappear with the Bell Beaker Culture and some Bell Beaker individuals were also buried in collective graves.

Effectively absent from the Linear Pottery Culture, flint axes first appear during the Villeneuve-Saint-Germain Culture, their frequency increasing at Middle, Late, and Final Neolithic sites, especially after 4200 BC. During these periods, flint axes are also encountered in collective burials. Implements produced from metamorphic and exogenous igneous rocks such as dolerite and amphibolite (of unknown origin) have been used for Linear Pottery axes, and more generally at Middle and Final Neolithic sites. During the late Neolithic, axes were ›dedicated‹ to the whole community of the dead close to entrances of the funerary chambers; they are common artefacts, some recycled and used (Sohn 2002; Sohn 2012).

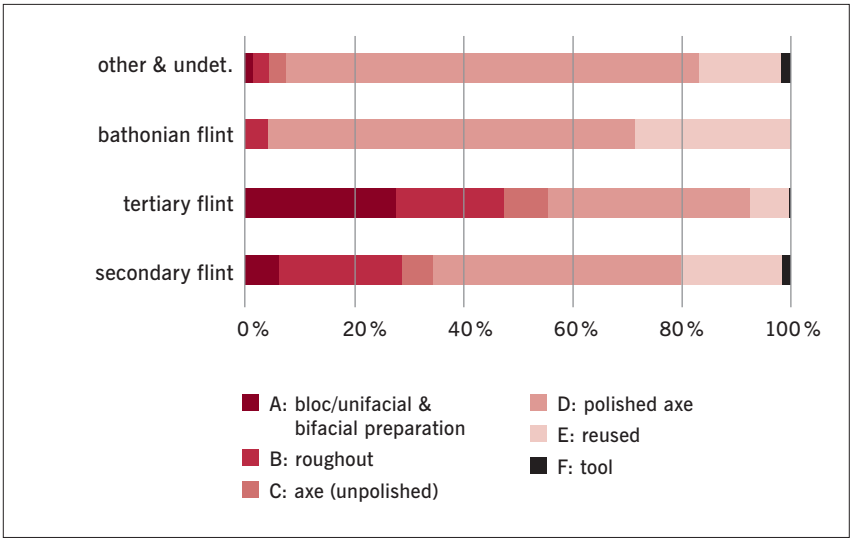

Fig. 3 Corpus of flint axes distributed by stage of the production process and material (total 2715 axes).

Abb. 3 *Die untersuchten Feuersteinbeile nach Herstellungsstufe und Material (gesamt 2715 Beile).*

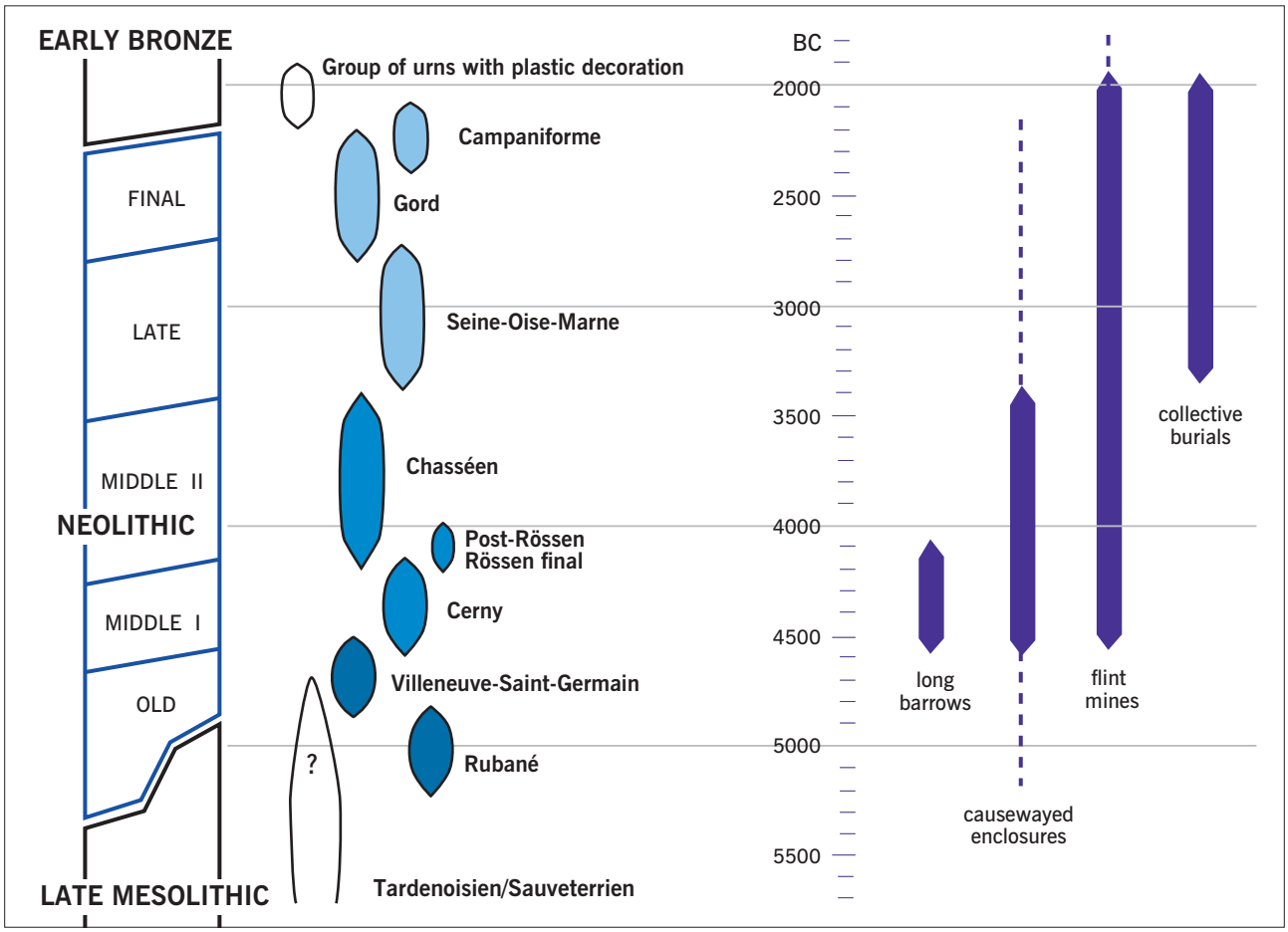

Fig. 4 Neolithic chronology in the Seine Valley.

Abb. 4 *Chronologie des Neolithikums im Seine-Tal.*

How flint axes were made

We have studied, preferentially, the biggest production site of the area, which is the Flins-sur-Seine, Dép. Yvelines (Île-de-France). The site dominates the valley of the Seine on a plateau at 100–125 m above sea level on a substrate of limestone and of loam with either superior Bartonian (Ludian) or inferior (Saint Ouen) limestone. Although there has never been an excavation on this site, we engaged in a systematic study of the mine through archaeological survey. The comparison of data from pedestrian prospection, geophysical survey, and arial views has revealed that the surface area with knapping workshops covers 15 ha, and the mine shafts between 3 and 5 ha (Fig. 5).

Finds include a range of waste and abandoned items reflecting all the technical stages of axehead production (bifacial preparations, roughouts, flaked axeheads), apart from polished objects. In addition, there are large tools on wide, thick blanks which may have been used for activities connected with mining, such as preparing the timbers required for shafts and galleries. Domestic and polished tools are rare; pottery and grinding stones are almost absent.

At this specialised extraction and knapping site, we were able to analyse the methods of axe production due to very large collections of roughout and waste. Analysis shows that knapping activities are almost exclusively related to the production of axe blades. Instead of few tools that could have been related to extraction activities, all finds and roughouts are dedicated to axe production. The axes were polished outside the mine or the workshop on standing stones or mobile polishing stones at the settlement areas nearby, a few kilometres from the site along the Mauldre Valley and on the alluvial plain.

Three main stages have been identified: bifacial preparation, roughout, and flaked axe (Fig. 6). The desired modules are between 8 and 14 cm in length (Bostyn et al. 2008, 87). Larger pieces are rarer at the mine (15 to 25 cm in length), and products from the early stages of manufacture have larger dimensions. We have observed a generally poor quality of production both for the raw material and in the levels of know-how, but there is no relationship between the quality of the raw material, the degrees of know-how, and the uniformity of the products. The flint is abundant, and even the best quality material could be used by knappers with little know-how. This supports the supposition of a direct access to the mine for the neighbouring inhabitants who do not exercise social control over the site. There have been reports of errors committed by apprentices or inexperienced knappers, who occasionally used bifacial techniques (Bostyn et al. 2008).

Bigger axes, interpreted as prestige productions, are rarely found in a workshop context (axes of 25 to 30 cm in

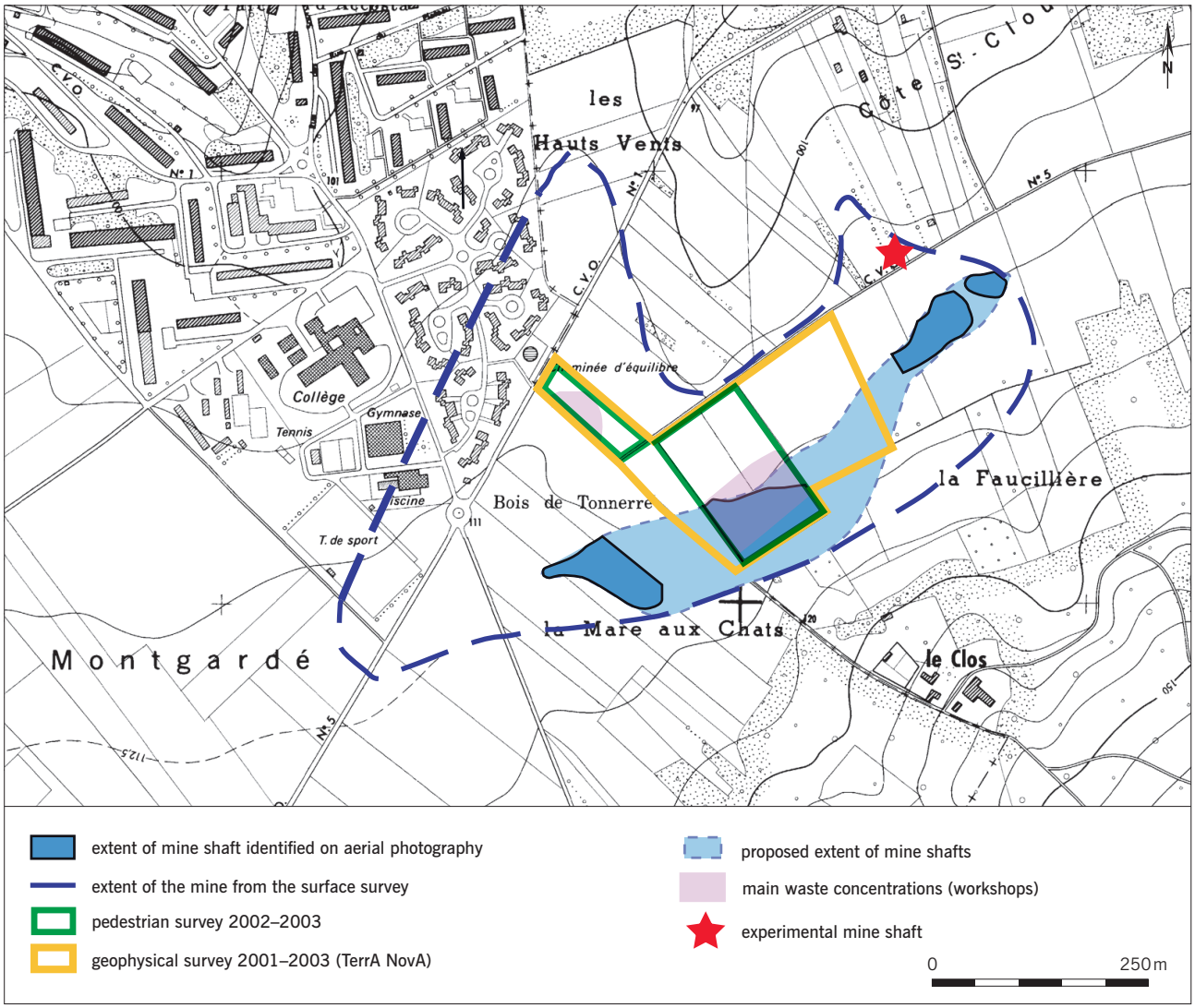

Fig. 5 Localisation of the main mining and workshop areas at the Flins-sur-Seine flint mine, Dép. Yvelines (Île-de-France).

Abb. 5 *Lage der wichtigsten Bergwerk- und Werkstattbereiche des Feuersteinbergwerks von Flins-sur-Seine, Dép. Yvelines (Île-de-France).*

length). Some of them have been found around the mine in the Seine Valley or on the plateau as surface finds. The large amount of abandoned intermediary products during fabrication allows us to analyse the reason for their abandonment: among them, knapping errors made during apprenticeship (Fig. 7). Although the principal cause of the suspension of work on these pieces is linked to the mediocre quality of the raw material, three main abandonment causalities due to the knappers know-how have also been identified and recorded: the first one is excessive concavities or hollows, the second one consist to knapp a flake overstepping the opposite edge to the percussion point, the third one is repeated errors of knapping angles. Some of them are more frequent in the first phases of the *chaîne opératoire*, some others at the latest stage (axe). The apprenticeship has become an actual theme for prehistoric research (Forte et al. 2023). Such research has been carried out in regard to the Casa Montero (Vicálvaro district) flint mine near Madrid (Spain), and a subsequent study has been made in the framework of a post-doctoral project (Castañeda 2018; Castañeda et al. in prep.). This research has proved the presence of apprentices with very little know-how, probably trained or authorised to train themselves by trial and error and accompanied by knappers who were experts in the extraction and production of axes.

Extraction work and specialisation

After analysing the axe production system, we asked ourselves the question of the know-how necessary for the extraction work and its degree of specialisation and the social context of this extraction. Of the different assumptions about access to raw material, direct access seems most likely, as no settlement is known on or near the mine. Thus, there is no village operating the mine in a privileged way, and, at the regional level, all communities could access it. The methods of extraction are seasonal because it is impossible to dig shafts in bad seasonal weather. One can imagine Neolithic peasants occasionally coming to extract flint blocks to make axes. The rest of the flint tools were produced with local resources at the settlement scale, flint

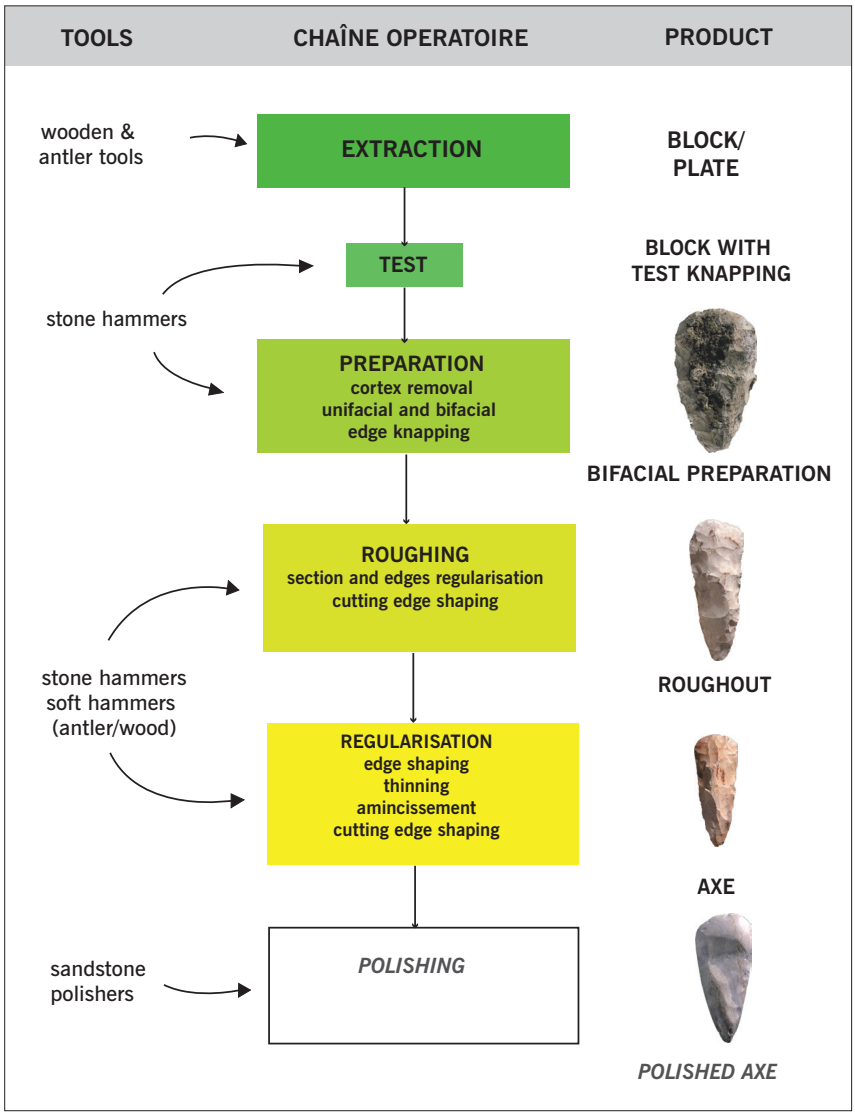

Fig. 6 *Chaîne opératoire* of axe making at the Flins-sur-Seine mine, Dép. Yvelines (Île-de-France).

Abb. 6 *Die* chaîne opératoire *der Beilherstellung am Bergwerk von Flins-sur-Seine, Dép. Yvelines (Île-de-France).*

being present almost everywhere in the settlement environment, as were the resources for clay pottery manufactured according to a domestic production mode. The question that can be asked is: Were there people with minimal know-how who would dedicate themselves to this task, even occasionally, or could this activity be practiced by all?

To shed light on this issue, we decided to construct an experimental mineshaft at the mine (Bostyn et al. 2009; Giligny/Bostyn 2015). The objectives were to define the nature of the know-how of Neolithic techniques by analysing:

- the techniques used, from the preparation of tools to the extraction of flint blocks,
- the effectiveness of the tools and their adaptation to the substrate, as well as the difficulties faced by the miners, and
- the time required to extract enough raw material to produce a dozen axes, and the number of people involved.

The tools used were reproduced in relation either to archaeological models (stone and deer antler tools) or according to their plausible character (mine rods, picks, and points). This work resulted in a photographic record and a documentary film of the main stages of digging, gestures, and postures during the experiment (Fig. 8)[2]. We also described the experimental material used and analysed the parameters of use (size, weight, breaks, reshaping, orientation of the edges, mode of use, etc.), and we performed a functional analysis of deer bone and flint tools under a high magnification microscope (traceology).

We concluded from this experience that digging a shaft is possible in a relatively short period with little know-how and human resources. It is estimated that, to dig a 2.50 m deep shaft, three people and about five to six days of their labour are enough. The most effective tools are the simplest, such as wooden tools, and the tools used for mining do not require special know-how: neither for their manufacture nor for their use. In Flins-sur-Seine, the stability

2 »En quête de silex«, documentary film by A. Lo Carmine, 25 min, <http://cinoeil.overblog.com/en-quete-de-silex> (06.06.24).

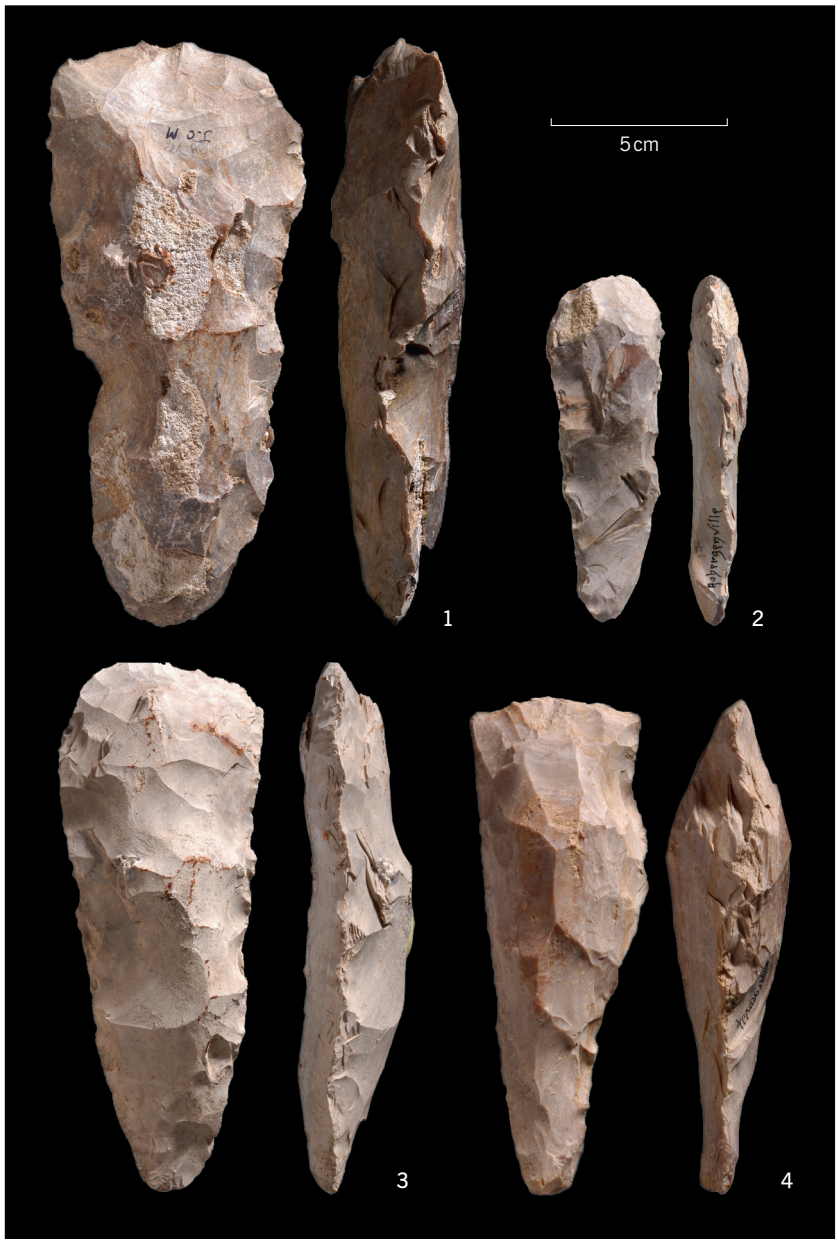

Fig. 7 Flins-sur-Seine, Dép. Yvelines (Île-de-France). Knapping errors and apprenticeship evidence during the axe-making process. 1 roughout: many hinged flakes; 2 bilateral bifacial roughout: hinged flakes, overstepped and concave flakes; 3 roughout: concave and hinged flakes; 4 bilateral bifacial roughout: obtuse edge with repeated traces of percussion (relentless).

Abb. 7 *Flins-sur-Seine, Dép. Yvelines (Île-de-France). Bearbeitungsfehler und Nachweise von Lehrlingstätigkeit bei der Beilherstellung. 1 Rohling mit zahlreichen Angelbrüchen; 2 Rohling eines zweiseitigen Faustkeils mit Angelbrüchen, Buchten und konkaven Abschlagsflächen; 3 Rohling mit konkaven Abschlagsflächen und Angelbrüchen; 4 Rohling eines zweiseitigen Faustkeils mit stumpfer Kante mit Spuren wiederholten Schlagens.*

of the sediment does not require any shoring or special precautions to avoid collapse until the mine shaft reaches the galleries below; specialised miners are therefore not essential.

The territory and distribution of axes

Although the Flins-sur-Seine mine is the largest in the Mauldre Valley, other flint mines and axe making workshops are known within an area of 20 km in diameter along the Mauldre Valley and River, a tributary to the Seine (Fig. 9), in addition to the large stationary polishing stones (relict sandstone block). Bartonian flint axe workshops are present at Jumeauville ›La Croix de Jumeauville‹, Montainville ›La Fauconnerie‹, ›Bloche‹, and Beynes ›Bois de Carcassonne‹ (all Dép. Yvelines, Île-de-France). Finds from these sites are identical to those from the Flins-sur-Seine mine, although the finds have a smaller surface, and the sites contained quantities of knapping waste. The sites are over 10 km from the mine and are located on the same geological formation of Saint-Ouen limestone. The position of mining in the territory must depend on the location of settlement areas and habitats: The mining is in an area empty of habitat indices, as is the case for the whole right bank of the Mauldre and the plateaus dominating it (absence of loess). Campanian Secondary flint axe workshops are also present, and the few mine shafts excavated at Maule ›Pousse-Motte‹, Dép. Yvelines (Île-de-France), have been dated to between the end of the Neolithic and the early Bronze Age (Simon 1986). The closest densely populated area is Epône, 3 km away, in the local supply area where people had to exploit mining seasonally. A small plain enclosure is located in the Seine Valley. No site on an elevated plateau is known, but one site is favourable to such a configuration (Jumeauville) and could have played the role of a central site (Fig. 10). This site combines settlements of all periods and contains evidence of axe workshops using Tertiary flint, but without

Fig. 8 Experimental reconstruction of mining techniques.

Abb. 8 *Experimentelle Rekonstruktion von Abbautechniken.*

extraction structures; it is located near a concentration of large sandstone stationary polishing stones. This territory regroups complementary sites dedicated to axe production: Mines, workshops, and polishing stones can be considered as a »mining complex« and a community area that is known to their inhabitants and their neighbours as an area of axe production and trade.

A study of the distribution of polished axe blades, either manufactured to completion or still in process, has been carried out to appreciate the spread of the products on a regional basis. There are differences in the distribution of products due to their position in the production sequence. The first stages of preparation, the bifacial and bilateral preparations, are very clearly concentrated at the mine and in nearby areas. The few points farther away show nevertheless that these unfinished pieces could circulate only rarely. The distribution of axe roughouts is less concentrated, showing diffusion towards the north, on the right bank of the Seine, and towards the southwest, at approximately 60 km. The polished axes have a larger and denser distribution. As an example, at the Louviers, Dép. Eure (Normandie), Middle Neolithic excavation site approximately 50 km from the mine, only the polished axes have been found, and they represent one third of the site's axe blades (Giligny 2005).

We also have evidence of axe trade from other production areas. Jade axes are quite abundant along the Seine Valley. There are also other materials, mainly from the Armorican Massif, such as dolerite axes. To the west, in western Normandy, we have a large axe production area in the Plaine de Caen-Argentan on the border between the Paris Basin and the Armorican Massif. The geological levels of the Jurassic contain flint in the Bathonian geological levels. Bathonian flint has been used since the Early Neolithic and from the Middle Neolithic; many flint miners exploited it to produce axes, for example, at Bretteville-le-Rabet, Dép. Calvados (Normandie), or Ri, Dép. Orne (Normandie; Ghesquière et al. 2021). Despite the fact that flint axes are produced in both regions and there is no need to import them, a number of Tertiary flint axes from the Seine Valley were found in the Caen-Argentan Plain and vice versa. Nearly fifty axes of Bathonian flint are known in the Seine Valley, and these exchanges demonstrate the contacts and social ties between these communities, although these exchanges are most likely not of an economic nature because they are not necessary.

The social value of axes in the Seine Valley in the Neolithic

At the end of this discussion, it is necessary to re-examine the central question posed during this conference: What is the social value of axes in the Seine Valley in the Neolithic,

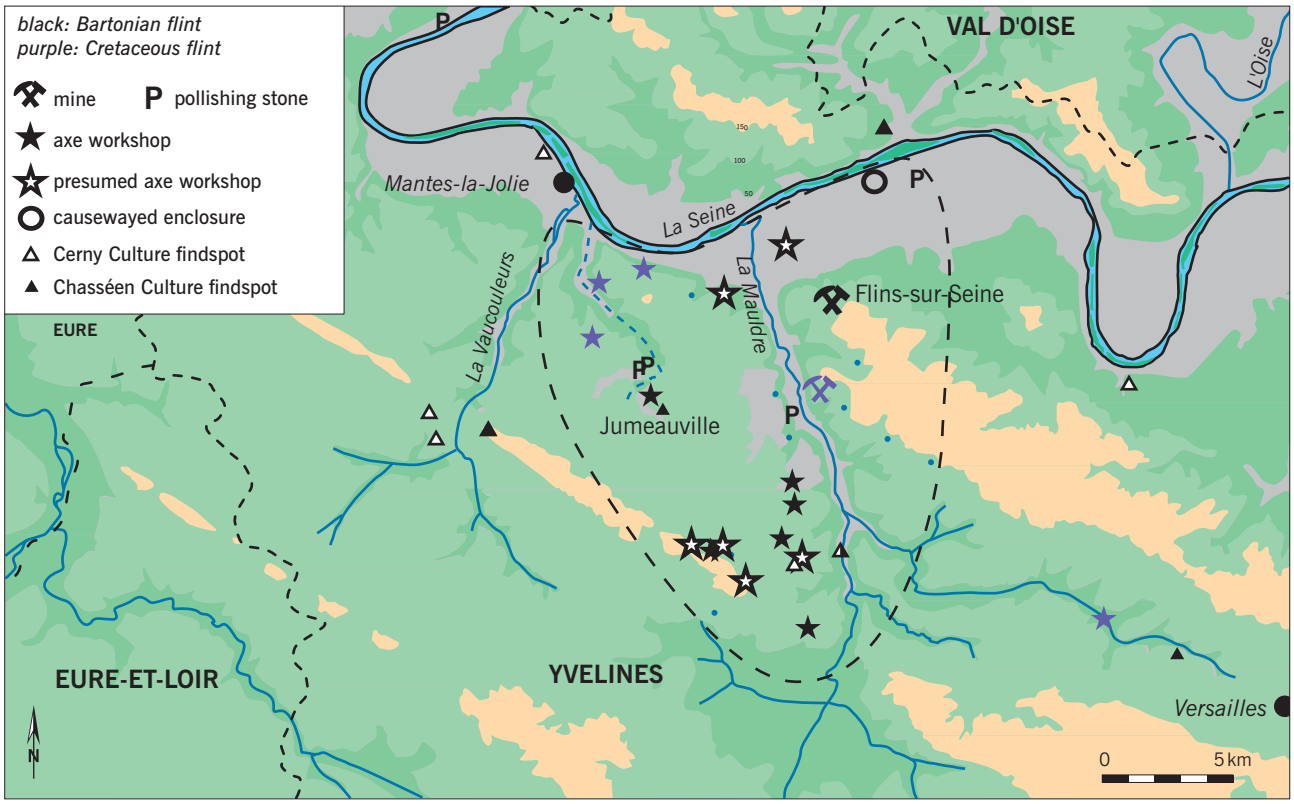

Fig. 9 Territory along the Mauldre Valley considered as a mining complex.

Abb. 9 *Gebiet entlang des Mauldre-Tals, das als Bergwerkkomplex gilt.*

given that this region produces large quantities of axes and exports its products to neighbouring regions.

First, we can investigate the manner in which the owners made use of these axes as a utilitarian object, for example, in everyday domestic applications and for wood cutting purposes, hence the so called ›work axes‹ (Fig. 11,1). Ethnographic models suggest that axes were used more by adult men. Are these axes a marker of gender and age? Are they

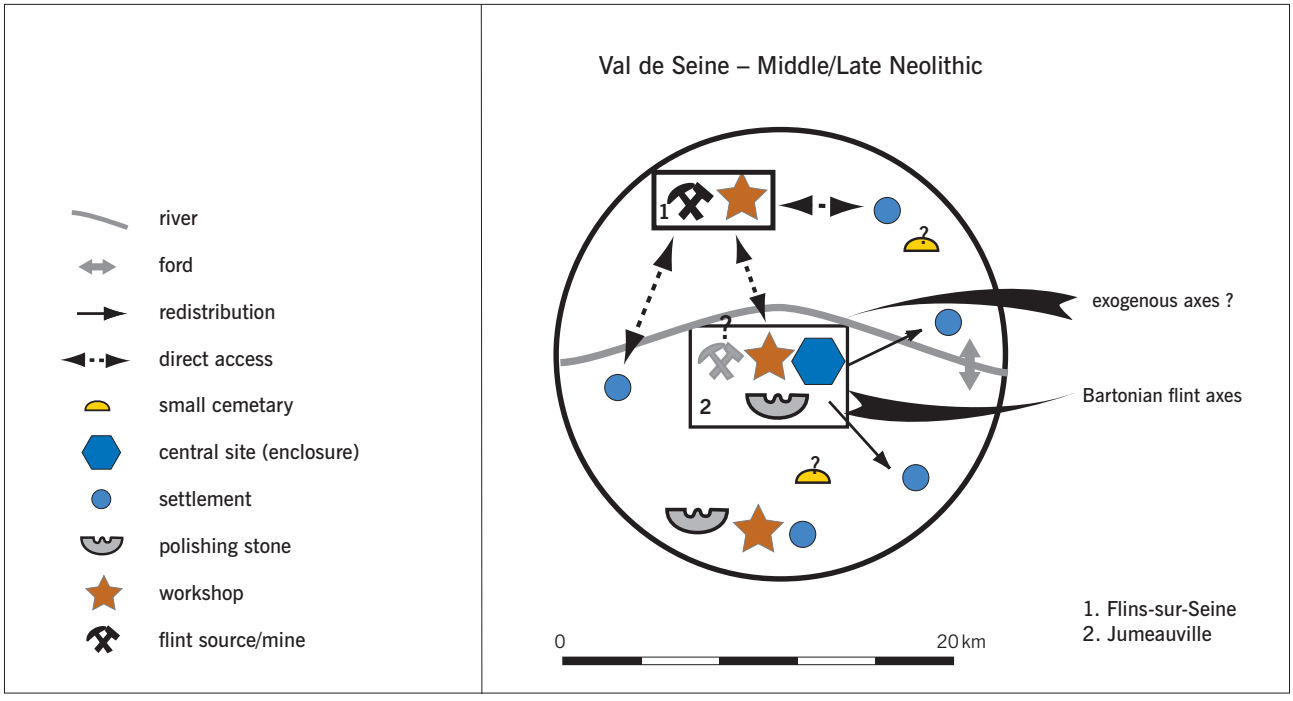

Fig. 10 Model of the mining complex along the Mauldre Valley.

Abb. 10 *Modell des Bergwerkkomplexes entlang des Mauldre-Tals.*

1

2

5 cm

3

considered as an exclusive good of their manufacturer or user, or, on the contrary, are they a common good of the household and used as such by all its occupants according to their needs? It is difficult to answer this question because the social organisation of Neolithic households is difficult to analyse, due to the lack of households excavated for the most consuming axes periods, like the Middle Neolithic II, Late, and Final Neolithic (4200–2200 BC). The abundance of these objects and their use as a collective offering in the collective graves of the Late and Final Neolithic suggest that they are considered, at this period at least, as a collective and community marker (Fig. 11,2), unlike arrowhead quivers and fire-starting kits that are associated with dead people (Sohn 2002; Sohn 2012).

Do the communities of the Mauldre Valley have their own identity linked to their role in the production of axes? Whether in the extraction of flint from the Tertiary or Secondary era, this region was producing large numbers of axes – axes that are then exported, either in the form of axes ready to polish, but also in the form of blanks, or even, across a smaller distance, as bifacial pieces. The origin of these axes – especially those found outside their geological region of origin, such as Tertiary flint, which is easily identifiable by its characteristics of texture and colour – had to be known, and this area of the centre of the Paris Basin would probably be named or at least identified.

The existence, in this valley of the Mauldre, of such flint mines and workshops for the production of axes raises questions about the social status of the miners, the axe-makers, and the neighbouring communities which, systematically over several centuries, exploited the production sites, including the very large Flins-sur-Seine mine.

During our experimental work, we have shown that, to dig shallow mine shafts (from 2 to 3 m), specialised know-how was not necessary. This is not the case for very deep wells operated with simultaneously exploited well group systems and communicating from one to the other shaft threw galeries such as in Jablines, Dép. Seine-et-Marne (Île-de-France), or Krzemionki in Poland. It is true that, in Flins-sur-Seine, we do not have excavations to verify the depth of the mine shafts, but the short distance between the shafts on the ground suggests a shallow depth: The distance between shaft-heads is always proportional to their depth in order to optimise the extraction work. If the miners of the Mauldre Valley are not to be considered specialists – and, in any case, it is a seasonal activity practiced by sedentary farmers and herders – they were probably identified within their village community as miners if they practiced this activity regularly and supplied the community. The status of miners and axe-makers in the community can probably evolve and be recognised socially, or even extended to all members of the same family or lineage. This is what one of the children's tombs at the site of Vignely ›La Porte aux Bergers‹, Dép. Seine-et-Marne (Île-de-France), seems to show, a burial that was found near the great mining complex of Jablines. In this tomb, a roughout, a polished chisel, and a polished axe are associated with a child from five to eight years of age (Chambon/Lanchon 2003). This child cannot be the producer of these finds, and these offerings are very rare during the late 5th millennium BC and are normally associated with high-status adult men. This status must have been inherited from the parents and affiliates. Few other graves contain axes in the same area, but they are all adult male graves. If a child inherits the status of his parents, then this status must be known to all within the community and associated with a certain prestige. This prestige can be linked to the quality and nature of exceptional products, such as large axes of 20 to 30 cm in length (perfectly regular, found as flaked or polished axes, and often unused), which can be associated with prestigious objects. Our hypothesis is therefore that these miners and makers of large axes had a particular social status transmitted from generation to generation. They probably did not have exclusive exploitation of the flint, which for the common and daily axes could be extracted and produced by all members of the community with direct access to the mine.

Since it has been proved that the mines and workshops were frequented by apprentices, one can also ask the question of the social status of apprentice knappers and their affiliation. Whereas the presence of the apprentices is well documented by the details of their technical failures and by the nature of their errors, which leaves no doubt about the poor quality of know-how of some beginners in the practice of bifacial knapping, their importance and recruitment are and probably will remain largely unknown. According to its definitions, learning can be described as a process of acquiring practices, knowledge, and skills (Wallaert-Petre 2001; Minar/Crown 2001). Beyond technical know-how, there is a significant social aspect, since it is also about acquiring habits, attitudes, and cultural values, which are part of the social identity of an activity or profession. An apprentice who excels technically but refuses the associated social and cultural values would be excluded from performing the activity or joining the profession, like a player who does not respect all the rules or codes.

If apprenticeship is a subject still rarely analysed in archaeology, it is the lithic productions that are best documented for this purpose. It is about the nature of the testimonies of apprenticeship and their preservation, including potentially the whole manufacturing process, thanks to the size waste and manufacturing failures at all stages of the operating chain. Studies of knapper apprenticeship show that the cultural context is paramount and that the transmission of these cultural values through the production of flint axes could be part of the social value of axes leading to an identity that is both individual – the knapper – but also collective – the axe-producing community. As for the scale of this community, it can be plural, that is to say, that of the family, the household, the village community, or the region producing axes. This design could of course be applied to other axe productions, whether stone or metal.

Another type of production questions the social value of axes: the so-called prestige products, which are *a priori* not

Fig. 11 (left page) Axes used as (1) everyday tools, (2) grave goods, and (3) prestige goods. 1 Louviers ›La Villette‹ (Eure); 2 Val-de-Reuil ›Les Varennes‹ (Eure); 3 Vigny (Val d'Oise).

Abb. 11 (linke Seite) *Beile als Alltagsgerät (1), Grabbeigabe (2) und Prestigeobjekt (3). 1 Louviers ›La Villette‹ (Eure); 2 Val-de-Reuil ›Les Varennes‹ (Eure); 3 Vigny (Val d'Oise).*

utilitarian but rather exceptional pieces (due to their size, the quality of their shaping, or their polishing) and which would be involved in strategies of power and social valorisation (Fig. 11,3). These products exist and are documented in this geographical region of western Paris, as we have seen. The local production of axes that would qualify as prestige is very present, whether the axes are made of Tertiary or Secondary flint. Unfortunately, in most cases, they can only be studied without find context, although a certain number can be interpreted as isolated deposits outside Neolithic human settlements (river banks, terraces, marshy areas, areas outside agricultural areas). In this sector of the Seine Valley, there are no individual graves that would contain large axes. Nevertheless, it would be surprising if the Neolithic societies were fundamentally different from their neighbours (valley of the Marne or plain of Caen). It is the ethnographic models, especially those developed on the highlands of New Guinea by Pierre and Anne-Marie Pétrequin (1993; 2006), that give us the best keys to reading Neolithic societies. The recurrent presence of these local products as well as the exogenous objects, which exist in fairly abundant quantities in the Seine Valley, would tend to show that individuals with the ability to hoard and ›consume‹ large axes more or less ostentatiously during collective events are present in our study area.

Conclusion

The work carried out in the Seine Valley led us to consider the production of axes as an identity marker of this Neolithic territory. Indeed, the production sites are abundant, and, for a long time, probably between 4200 and 2200 BC, the production process was carried out at the community and regional scale on several extraction sites and at surface workshops. These extraction activities are certainly important from a cultural and social point of view, and they have been significant, not only for individuals – miners or axe knappers – but also for their families, households, and villages, i.e., for the entire regional community. The transmission of know-how from generation to generation together with the apprenticeships in shaping the size of bifacial parts, as we have seen at the mining site of Flins-sur-Seine, are a means of transmitting this technical and cultural tradition. The import of exogenous materials, be it axes made of the solid rock of distant mountain massifs, the Alps, or the Armorican Massif, but also axes of flint that could very well be produced locally, illustrates the insertion of Neolithic communities within the Seine Valley into interregional networks and their connection with all neighbouring regions. This social link that is generated by exchanges is also part of the social value of the axes we are talking about here. Finally, and despite the weakness of the regional archaeological contexts that would allow us to go further (but using what we know from the Paris Basin), individuals in the valley of the Marne or in Normandy who belong to an elite have very probably exploited some exceptional objects or prestigious axes for the purpose of power and the social valorisation of their symbolic role or for their use in burial rites, for example. A utilitarian, economic, and social object, the stone axe symbolises Neolithic cultures and their complexity.

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Polished axes: A factor in social integration on a local and supra-local scale?

Véronique Brunet

Zusammenfassung

Polierte Beilklingen: Ein Faktor der sozialen Integration auf lokaler und überlokaler Ebene?

Für die Herstellung von Beilklingen liegen Belege für die langanhaltende Zeit der Bergwerkstätigkeit in Jablines in Seine-et-Marne (Île-de-France) zwischen 4230 und 3495 cal BC vor. Es handelt sich bei den Beilklingen um typische Produkte dieser Silexwerkstätten (Bostyn/Lanchon 1992). Neuere Untersuchungen zur Organisation der Verarbeitung bartonischen Silex' im Tal der unteren Marne zur Zeit der Michelsberger Kultur (4200–3600 v. Chr.) haben – völlig unerwartet zusammen mit spezialisierten Silexwerkstätten in benachbarten Siedlungen – weitere Fundstellen von Orten der Beilherstellung ans Licht gebracht.

Tatsächlich zeichnet sich das Gebiet durch eine ungewöhnliche Organisation der Herstellung aus, denn die Werkstätten zur Silexbearbeitung befanden sich sowohl im häuslichen als auch im Bergwerksbereich. In den Silexminen wurden zwei Typen von Beilklingen hergestellt: 20–30 cm große und kleinere mit einer Länge von 15–17 cm (Bostyn/Lanchon 1992). Parallel dazu stammen 15–17 cm messende Beilklingen auch aus häuslichen Silexverarbeitungsstätten (Brunet 2021; Brunet 2022). Wirtschaftliche Gründe dafür sind nicht erkennbar, denn wieso sollten sowohl große als auch kleine Beile in Jablines hergestellt werden und dann noch die kleineren zusätzlich in benachbarten Siedlungen?

Für wen und weshalb wurden die Beile hergestellt, wenn diese Produktionsgüter aus dem Bereich der Bergwerkstätten nicht an benachbarte Siedlungen weiterverteilt wurden? Die bilokale Produktion von Beilen aus bartonischem Material im Gebiet von Jablines dient als Beispiel, um soziale Integration auf lokaler und überlokaler Ebene zu analysieren.

Schlagwörter Mittelneolithikum, geschliffene Beilklinge, Silex, soziale Funktion

Summary

The production of axe blades is attested during the long period of exploitation of the Jablines mining site in Seine-et-Marne (Île-de-France) between 4230 and 3495 cal BC, and is one of the emblematic products of these flintknapping workshops (Bostyn/Lanchon 1992). Recent research on the organisation of the Bartonian flint production in the lower Marne Valley during the Michelsberg Period (4200–3600 BC) has shown, contrary to all expectations, that there are other axe production sites in neighbouring settlements with specialised flintknapping workshops.

In fact, this territory is characterised by an original organisation of this production, since it was carried out both in flint mines and in domestic flintknapping workshops. In the flint mine, two types of axes were produced: large 20–30 cm modules and smaller 15–17 cm modules (Bostyn/Lanchon 1992). At the same time, axes measuring between 15–17 cm were also made in domestic flintknapping workshops (Brunet 2021; Brunet 2022). There seems to be no economic justification for this, for why would both large and small axes be produced in Jablines but the smaller ones also in neighbouring settlements?

For whom and why were these axes made, given that the products of flint mining were not redistributed to neighbouring settlements? The dual production of Bartonian axes in the Jablines area is used as an example to analyse the expression of the factor of social integration at the local level and integration at the supra-local level.

Keywords Middle Neolithic, polished axehead, flint, social function

Introduction

Our research aims to reconstruct the spatial organisation of the flint industry economy of all categories of Michelsberg sites (Middle Neolithic II: 4250–3600 BC). This will allow us to document the qualitative and quantitative differences between producer and consumer sites. We investigate the socio-economic implications of the Neolithic polished axe and its social value by comparing the scale of production depending on where it was made and how it was used locally and on a supra-local scale.

Our study area is located to the east of the Paris conurbation (Fig. 1) and is centred on the downstream basin of the Marne in the north of the Seine-et-Marne Département. It extends between the valley floor and the adjacent plateaux (Fig. 2). The Marne basin downstream is known for its abundant Bartonian Tertiary flint, which has been extensively mined since the Middle Neolithic II period. It pro-

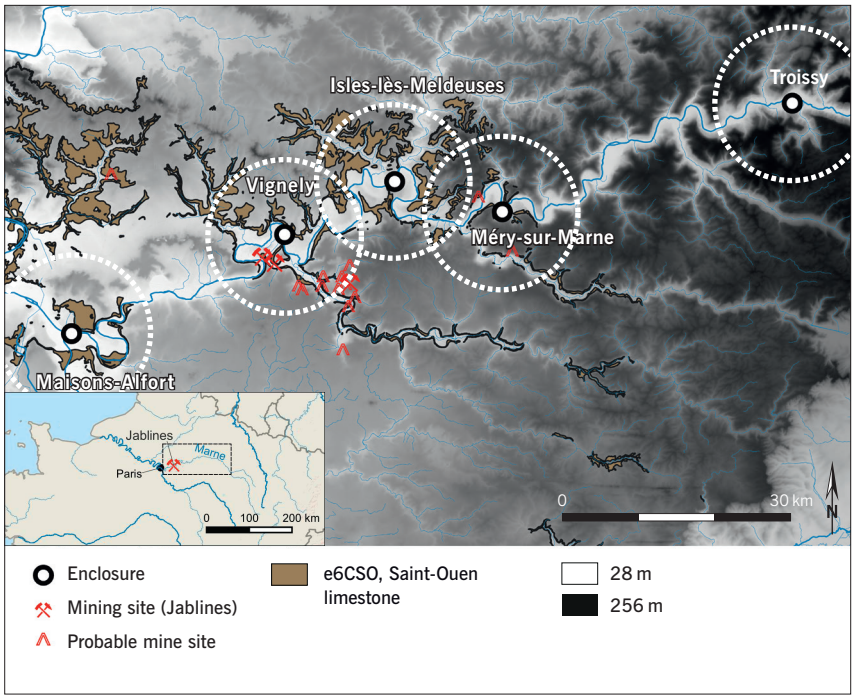
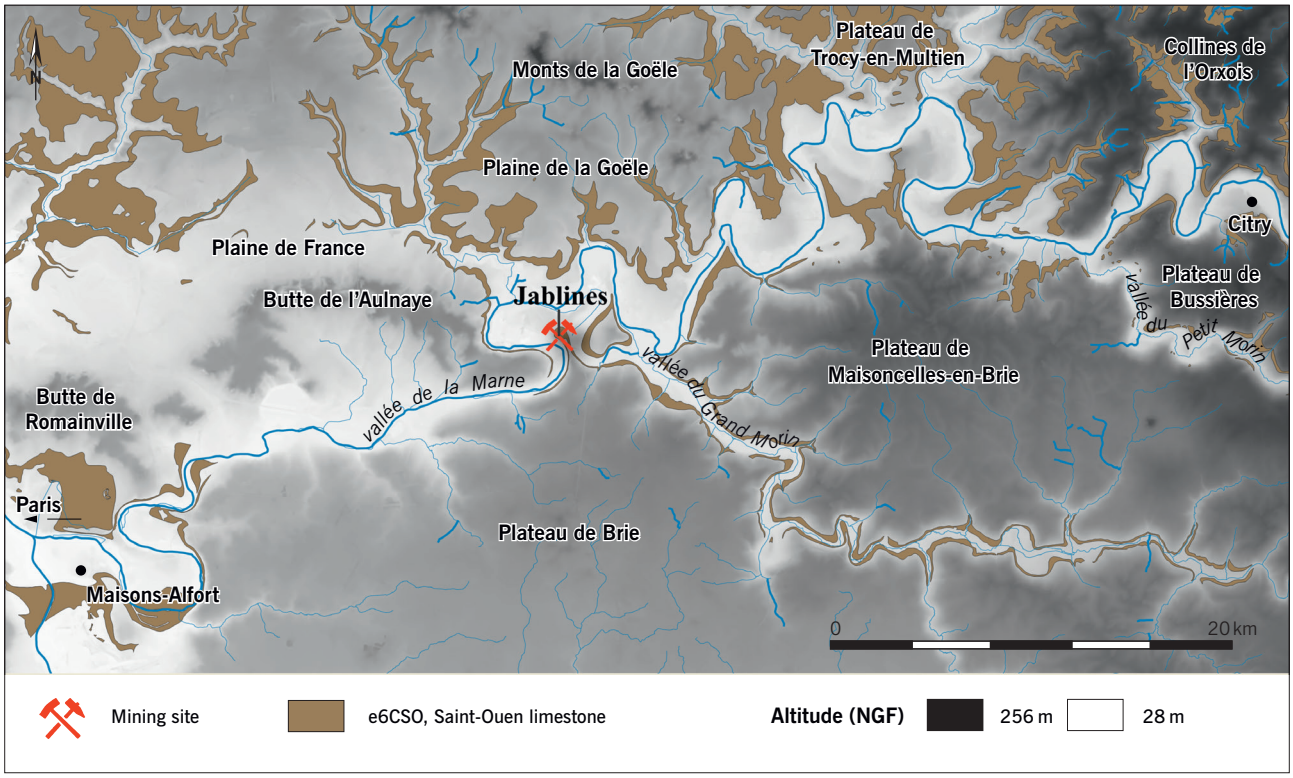


Fig. 1 Enclosures in the lower Marne Valley (the presumed mining areas or mining complexes are represented by the white dotted circles). On this map, you can see the downstream basin of the Marne with the Jablines flint mine in the middle; the limestone of Saint-Ouen is shown in brown, the main outcrops of which contain numerous banks of (Bartonian) flint in the form of flint slabs.

Abb. 1 *Erdwerke im unteren Marne-Tal (der vermutete Bergbaubereich/-komplex ist durch die weiß gepunkteten Kreise dargestellt.) Die Karte zeigt das flussabwärts gelegene Becken der Marne mit der Silexmine von Jablines in der Mitte. In Braun sind die Kalksteinvorkommen von Saint-Ouen dargestellt. Die Hauptvorkommen enthalten zahlreiche Silexaufschlüsse (bartonisch) in Form von flachen Silexplatten.*

Fig. 2 The valleys and plateaux of the lower Marne Valley.

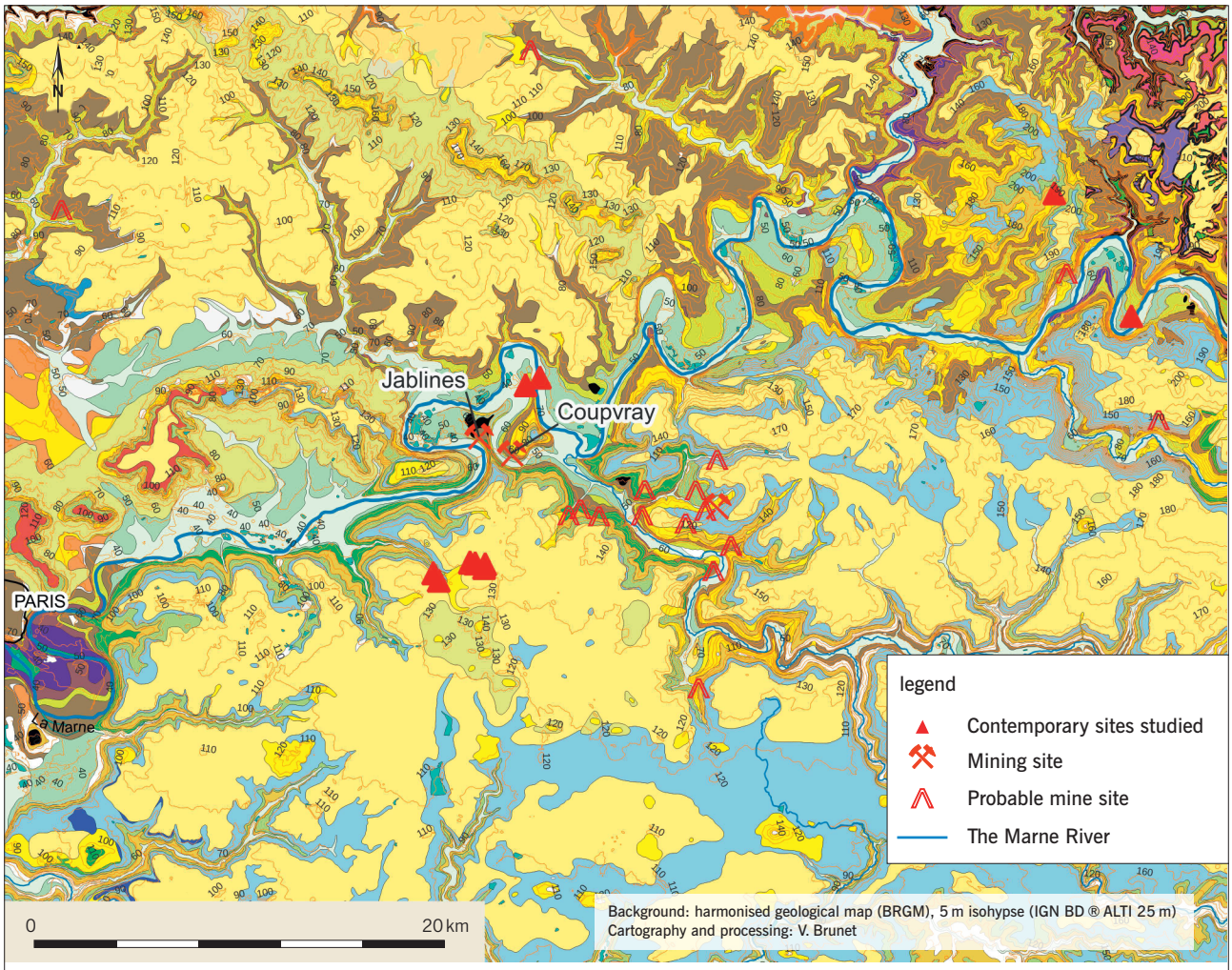
Abb. 2 *Die Täler und Ebenen des unteren Marne-Tals.*



vides an opportunity to study the working of a flint mining complex, centred around a flint extraction site at Jablines in Seine-et-Marne, which is undoubtedly the largest in the northern half of France.

The Marne Valley contains several siliceous deposits. In 1992, F. Bostyn identified various formations (Bostyn/Lanchon 1992). The Brie plateau consists of an Eocene marl formation (Marnes supragypseuses, Ludien) and two Oligocene formations: the Brie limestone and the green clays (Fig. 3). These formations are covered by a several-metre-thick Quaternary deposit of plateau silts (according to the BRGM 1/50 000 geological map[1]). The Jablines flint mine excavation (Bostyn/Lanchon 1992, 34–38) uncovered multiple middle Bartonian silicification levels with distinc-

1 Harmonised geological map (BRGM), 5 m isohypse (IGN BD ALTI 25 m). BRGM map base. Shapes can be downloaded from: <https://infoterre.brgm.fr/> (05.04.2024); <https://infoterre.brgm.fr/page/telechargement-cartes-geologiques> (05.04.2024).



Legend for the harmonised geology map

- CE, Polygenic colluvium, scree slopes – 2
- CF, Slope and valley bottom colluviums – 4
- LP, Plateau silt – 9
- Fz, Recent alluvium: silts, clays, sands, peat in places – 16
- Fy, Ancient alluvium (low terrace 0–10 m): sand and gravel, colluvium, alluvium and aeolian deposits – 17
- Fx, Ancient alluvium (average terrace of 10–20 m): sand and gravel – 18
- g1SF, Fontainebleau sands, with occasional sandstone in place or with little reworks (slope) – 40
- g1MH, Oyster marl and Corbulus clay – 46
- g1CB, Stampian Brie limestone and plio-quaternary millstone undifferentiated – 47
- g1AR, Green clay, Cyrenic clay and/or Green and white marls (Romainville green clay) – 51
- e7MS, Supragypseous marls: white marls of Pantin, Blue marls of Argenteuil – 53
- e7G, Gypsum masses and marls – 55
- e7G-MP, Masses and marls of gypsum, marls with Pholadomya ludensis – 57
- e7CCh-MP, Champigny limestone, marls with Pholadomya ludensis
- e6SM, Monceau sands – 65
- e6CSO, Saint-Ouen limestone – Nogent l'Artaud limestone and marl l'Artaud, Ambreville limestone, Branles limestone – 67
- e6SB-A, Sands of Beauchamps, sands of Auvers (Beauchamp and Auvers = Val-d'Oise) – 71
- e5MC, Marls and stones – 74
- Hydro, Hydrographic network, flooded gravel pits – 96

Fig. 3 Geological context of the downstream Marne basin.

Abb. 3 *Geologischer Kontext des flussabwärts gelegenen Marne-Beckens.*

tive siliceous bed formations. Among the five identified beds, two were exploited in the Neolithic, in particular the middle Bartonian Tertiary flint from the Saint-Ouen limestone formation e6CSO (cf. Fig. 1; brown on the map). The flint is more or less deeply buried and is overlain by several layers of sandy marl measuring between 0 and 5 m in thickness. Flint is abundant and has excellent knapping qualities.

During the Middle Neolithic II, enclosures multiplied and flint mining was intensively exploited. This period also witnessed the emergence of social complexity. During the Middle Neolithic in the Marne Valley, evidence of flint mining can be seen from the Middle Neolithic I at Cerny (4700–4300 BC) (Bostyn/Lanchon 1992); necropolises appeared (Chambon/Lanchon 2003; Bostyn et al. 2018), followed by enclosures (Lanchon et al. 2006; Brunet et al. 2021b;

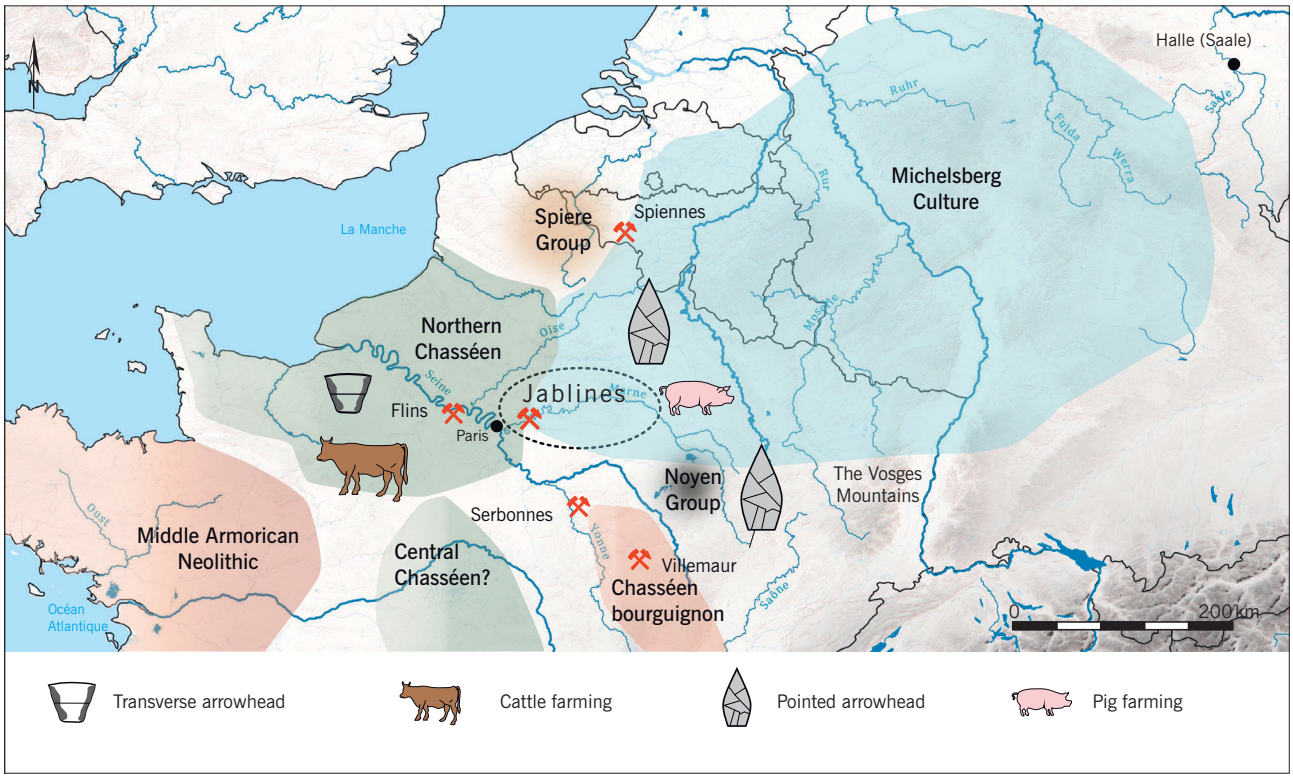


Fig. 4 Cultural groups of the Middle Neolithic II in the Paris Basin and adjacent areas.

Abb. 4 *Kulturgruppen des Mittelneolithikums II im Pariser Becken und angrenzender Gebiete.*

Brunet et al. in press) and open settlements[2] during the Middle Neolithic II.

Territorial models in the Paris Basin revolve around the development and function of enclosures. These features are not evenly distributed and are concentrated in specific areas, such as the valleys of Yonne, Marne, Aisne, and Oise[3]. The established models distinguish between site types that are linked to varying degrees of social integration, such as households, villages, and regions. This is based on their structural and spatial characteristics. These characteristics include large lowland enclosures, barred spurs, small lowland enclosures, large lowland villages, and small lowland settlements. It is important to note that these site types are associated with different levels of social integration (Dubouloz 1989; Dubouloz 2018; Liétar 2014).

The concept of a mining complex originated in France, according to the data obtained from rescue archaeological excavations. The term is used to describe a larger group of similar or complementary sites »within the same geomorphological unit« related to lithic production (extraction sites, flintknapping workshops, polishing sites) as well as to settlements and megaliths (de Labriffe/Thebault 1995, 49); alternatively, it is used to describe a more restricted group of »sites exploiting the same flint, in more or less the same geological and topographical conditions« (Bostyn/Lanchon 1992, 221).

These two definitions are illustrated by the example of the Marne region in Seine-et-Marne, our study area.
Mining sites may or may not coexist with enclosures, depending on the region. In regions where they coexist, various territorial models have been developed, such as those in the Marne Valley (Brunet 2022) and in the Mauldre Valley in the Yvelines with the Flins flint mine, enclosure, and settlements (Giligny et al. 2016). Flint mines can be found in Yonne, such as the Serbonnes flint mine and enclosure[4]. The Spiennes flint mine, located in the Mons Basin of Belgium, is one of Europe's major mining centres. The site's particular originality lies in the fact that an enclosure was built in the immediate neighbourhood of the extraction site (Collet 2004; Collet/Collin 2023) (Fig. 4). The production of pelite-quartz in the Vosges serves as an example of the role of enclosures in disseminating and controlling mineral resources, such as salt (Jeudy et al. 1995; Pétrequin et al. 1995; Weller 2010).

This shows the importance of enclosures in the management and distribution of valuable resources.

During this period, our region has seen major changes that have had a profound impact on its territorial structure. These changes have led to an increase in the functional differentiation of sites. In addition to the valley bottoms, which have been occupied since the Early Neolithic, the plateaux

2 Brunet/Le Jeune 2008; Aubry et al. 2014; Brunet/Blaser 2015; Brunet/Colas 2018; Brunet 2021.

3 Dubouloz 1989; Dubouloz 2018; Dubouloz 2018a; Dubouloz et al. 1991.

4 Augereau 2004; Augereau 2008; Augereau/Bostyn 2008; Augereau et al. 2021.

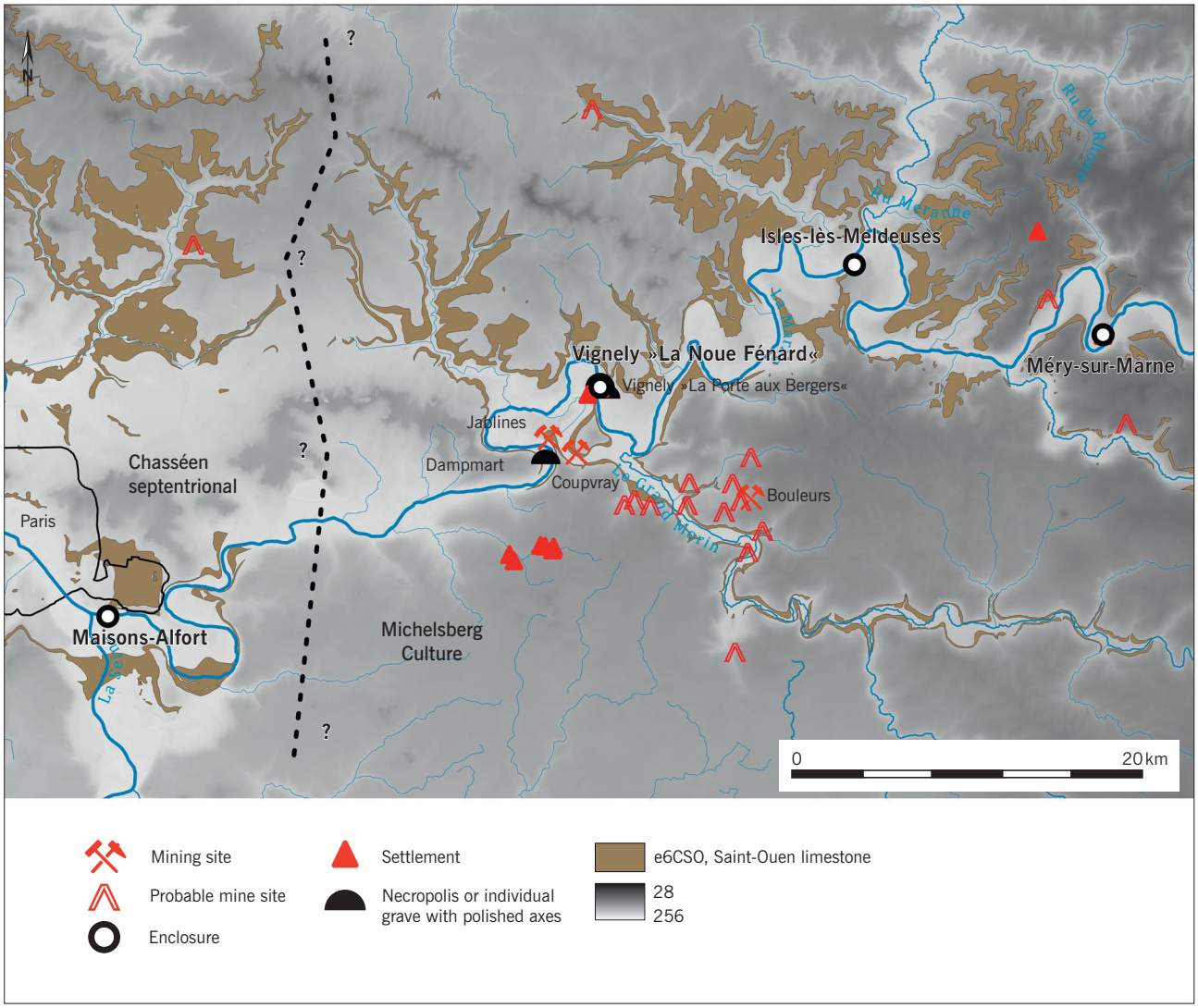


Fig. 5 The Lower Marne Valley during the Middle Neolithic II: situation and cultural groups.

Abb. 5 *Das untere Marne-Tal während des Mittelneolithikums II: Lage und Kulturgruppen.*

have now been developed (Augereau/Bostyn 1997; Augereau/Bostyn 2008).

During the Middle Neolithic II, the Paris Basin was occupied by several cultures with varying areas of influence. These included the Michelsberg Culture (4200–3600 cal BC) to the north and east (clearly seen in the Aisne and Marne Valleys), the Northern Chassean Culture to the west, and the Noyen Group to the south. The arrowheads found in the Paris Basin indicate a clear opposition between the Northern Chassean and the Michelsberg Cultures. The difference between the Northern Chassean and the Michelsberg Cultures is clearly seen in their arrowheads. The former predominantly used transverse arrowheads, whereas the latter favoured pointed ones (Augereau/Bostyn 2008; Manolakakis/Garmond 2011). The Michelsberg region in the north-east of the Paris Basin developed an economy centred around pig farming for subsistence, while the Chasséen region in the north favoured cattle farming (Hachem 2011).

From a cultural perspective, the Marne Valley is at the intersection of the Michelsberg area to the north-east, the Northern Chassaen to the west, and the Noyen Group to the south (Fig. 5). Defining the boundary between the two cultures can be difficult.

The Marne Valley has yielded five enclosures: Maisons-Alfort, Vignely «La Noue Fénard», Isles-lès-Meldeuses, Méry sur Marne «La Remise», and Troissy. These are located from east to west, starting at the edge of the Bartonian outcrop in the Marne and ending at the confluence of the Seine and Marne Rivers in Val-de-Marne (cf. Fig. 1; cf. Fig. 5; Fig. 6). The documentation of these sites is not uniform, as the ones at Maisons-Alfort (Cottiaux et al. 2008), Vignely (Lanchon et al. 2006), and Méry-sur-Marne (Bulard et al. 1996; Brunet 2021a) have been the subject of rescue excavations and provide high-quality information. In contrast, the ones at Isles-lès-Meldeuses and Troissy are only known from aerial surveys (Brunet 1999). The enclosures at Vignely and Méry-sur-Marne indicate that local Bartonian flint was predominantly used, suggesting a close relationship with the mining sites in the area. The settlements yielded almost no Cretaceous flint, in contrast to the quantities found in the enclosures, indicating a privileged relationship with distant regions (since the nearest Cretaceous outcrops are around

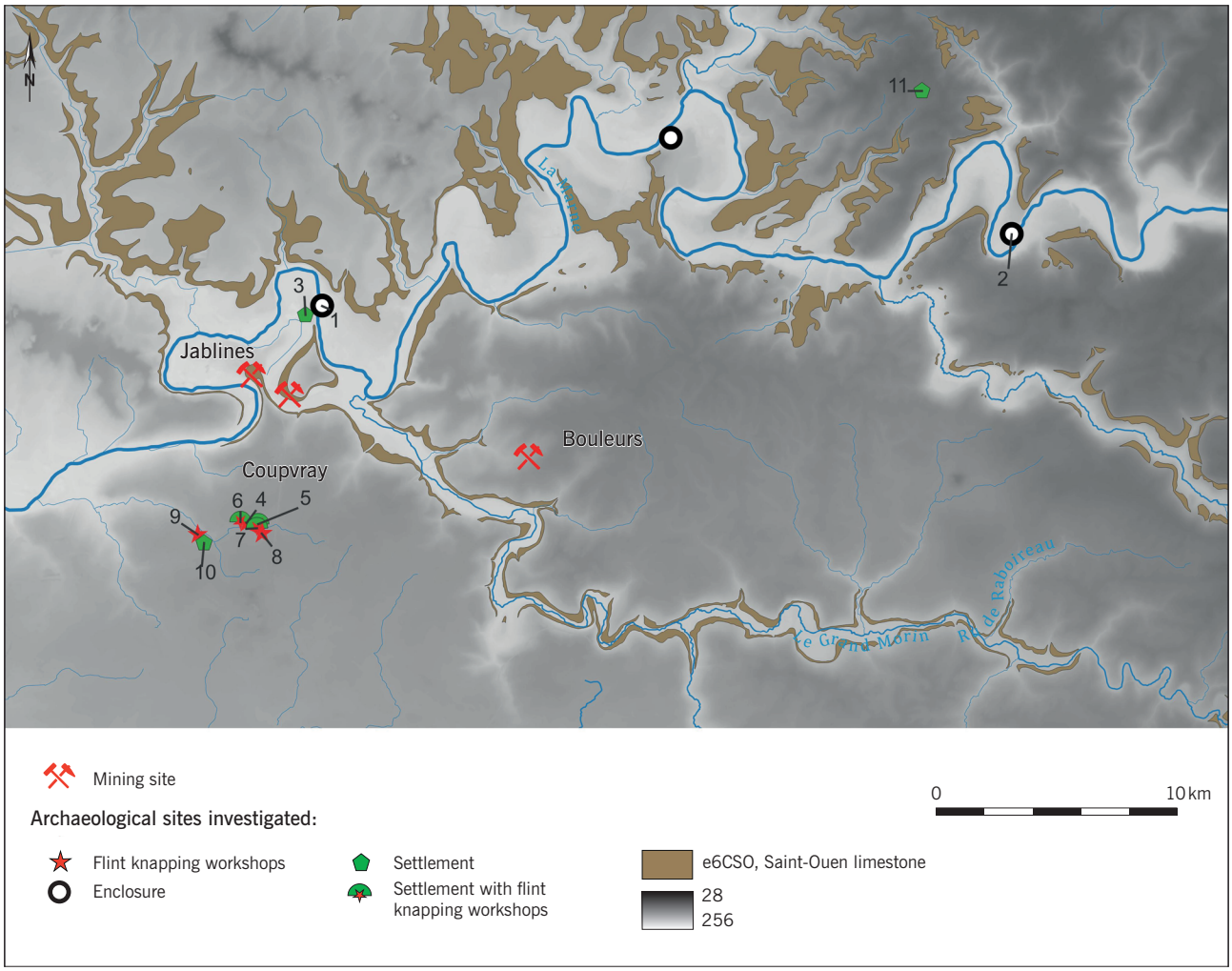


Fig. 6 Location of the Middle Neolithic II archaeological sites investigated.

Abb. 6 *Lage der untersuchten Fundplätze des Mittelneolithikums II.*

1 Vignely, La Noue Fénard; 2 Méry-sur-Marne, La Remise; 3 Lesches, Les Prés du Refuge; 4 Montévrain, ZAC du Val d'Europe- Lot I1; 5 Montévrain, ZAC Université; 6 Montévrain, ZAC du Clos Rose; 7–8 Jossigny, Le Pré du But; 9 Bussy-Saint-Georges, La Manjoire; 10 Bussy-Saint-Georges, ZAC des 100 Arpents; 11 Dhuisy, ZA Les Effaneaux.

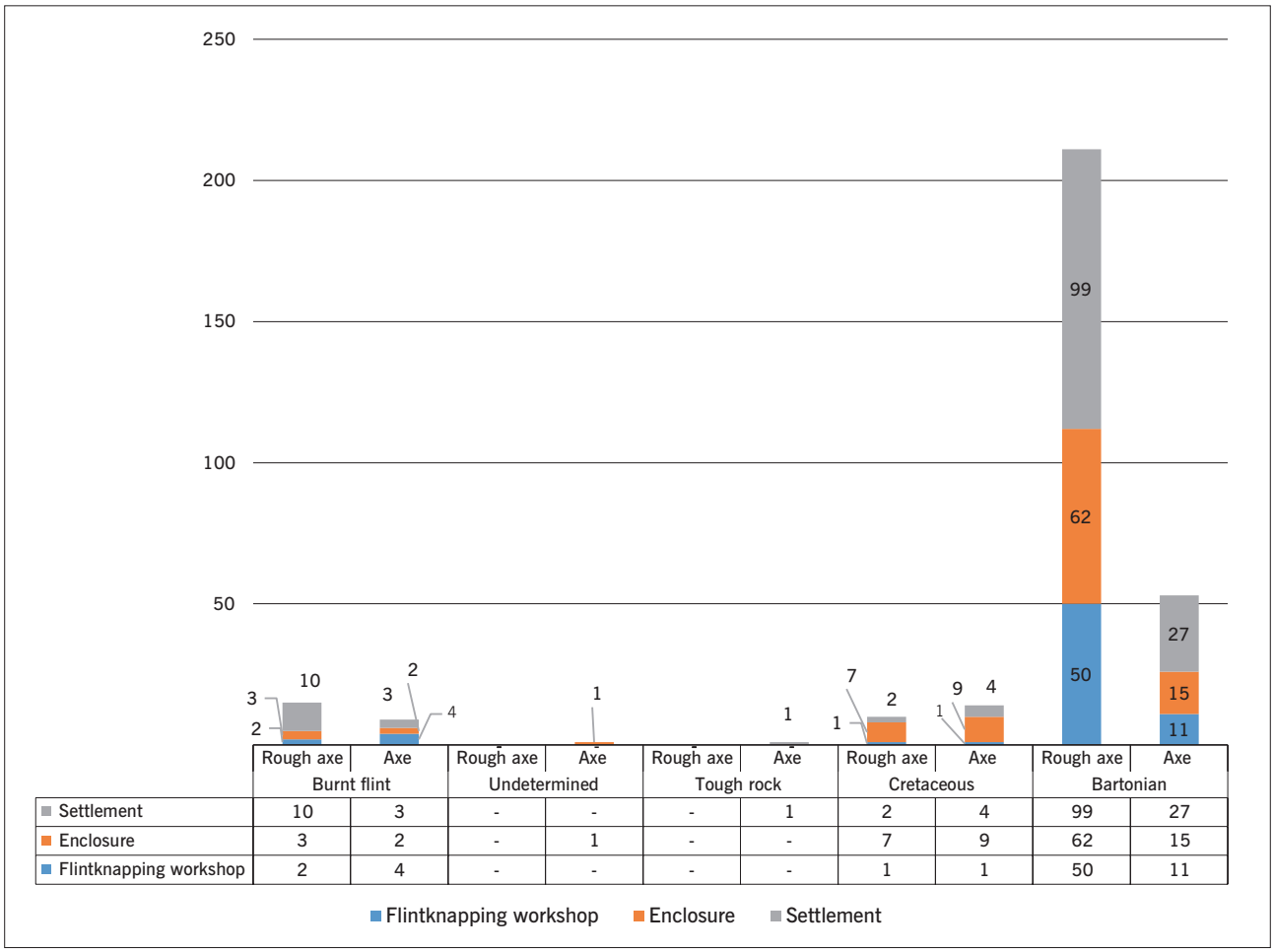
50 km away) in other cultural entities, such as the Northern Chassean, for example. The role of enclosures in the management and distribution of resources seems significant.

The mining complex currently consists of three mining sites: Jablines (Bostyn/Lanchon 1992), Coupvray (Giraux/Reynier 1911), and Bouleurs (Borgnon 2003). Only Jablines has been excavated so far (cf. Fig. 5). Additionally, there are 18 probable extraction sites located at the confluence of the Marne and Grand-Morin Rivers.

Settlements with houses and flintknapping workshops specialising in axe blades, such as those at Jossigny and Montévrain, can be found on the plateau[5]. The durable domestic space is organised around houses where various craft activities are carried out to process different materials (flintknapping workshops, sandstone-shaping, polishing, silos) and for subsistence. The flint used in the Bartonian settlements is highly homogeneous and is believed to come from silex mining sites, particularly the Jablines site, which shows close links with the silex mining sites.

The lower Marne Valley has a well-documented burial landscape; a small monument and three pit burials were excavated at Vignely, «La Porte aux Bergers» (Chambon/Lanchon 2003; Bostyn et al. 2018). Two burials were found inside a ditch 800 m from the enclosure of «La Noue Fénard» and a third was contemporaneous with the enclosure outside it (Lanchon et al. 2006; Brunet et al. in press). A further inhumation was also discovered in a previously excavated grave at Dampmart (Bostyn 2015). It should be noted that four of these burials yielded polished or roughout axes, which are not part of the usual grave goods of Middle Neo-

5 Brunet 2007; Brunet 2021a; Brunet/Le Jeune 2008; Brunet/Blaser 2015; Brunet/Colas 2018; Brunet et al. in press.



	Burnt flint		Undetermined		Tough rock		Cretaceous		Bartonian	
	Rough axe	Axe	Rough axe	Axe	Rough axe	Axe	Rough axe	Axe	Rough axe	Axe
Settlement	10	3	-	-	-	1	2	4	99	27
Enclosure	3	2	-	1	-	-	7	9	62	15
Flintknapping workshop	2	4	-	-	-	-	1	1	50	11

Fig. 7 Rough axe heads and polished axes by raw material, by context of discovery (nb).

Abb. 7 *Geschliffene (Axe) und ungeschliffene (Rough axe) Beilklingen nach Rohmaterial und Fundkontext.*

lithic II burials. According to Bostyn, this suggests a relationship between the burials and the enclosure (Bostyn/Collet 2011).

Procurement strategy, raw materials management, and manufacturing

In the Boucle de Jablines area, the Michelsberg settlements are located between 5 and 6 km from the nearest flint mines (Jablines and Coupvray), on the northern fringe of the Brie plateau, i.e., just over an hour's walk away. The supply area is characterised by an abundance of local flints (Bartonian) and accounts for 95 % of the overall supply from the deposits studied, whereas Cretaceous flints account for only 1 % of the total weight.

The evaluation of the lithic material shows significant differences according to the type of occupation. Settlements with several flintknapping workshops yielded the largest quantities of lithics, totalling between 300 and 450 kg per site. On the other hand, the two palisaded enclosures, despite having identical excavation areas, yielded very different quantities, ranging from 14 to 54 kg. In total, the various excavations yielded one tonne of siliceous lithic material, of which 704 kg was analysed, representing a statistically reliable sample.

We have a sample of 314 pieces from a bifacial, trihedral or spheroidal preparation distributed between 10 occupations, three of which are located at the bottom of the valley (enclosure) and seven on the northern fringe of the Brie Plateau (settlements): 99 come from the two enclosures and 215 are distributed between the 7 settlements. In this sample, there are 78 polished axes (51 in settlements, 27 in enclosures), the remainder are rough axe. In summary, all the stages of the bifacial *chaîne opératoire* are present at all the settlements on the plateau, showing that this type of production was carried out in all of them (Fig. 8–9).

The rare whole specimens that have come down to us from the sample described above show non-local flint axes that are slightly longer than local domestic Bartonian axes. The length-to-width ratio of Cretaceous axes is 3.5, whereas that of Bartonian axes is 2. On the other hand, the width-to-thickness ratio is higher for local flint examples (1.8) than for polished blades in regional flint (1.4). In the downstream Marne basin, the polished blades are shorter and more compact, perhaps a morphological specificity of the Marne Valley. Of the 78 polished axes recorded in our corpus whose shape can be identified, five are trapezoidal and three are quadrangular (the vast majority of which are broken). The cross-section is biconvex, sometimes very flat. There is nothing systematic about the presence of lateral flats.

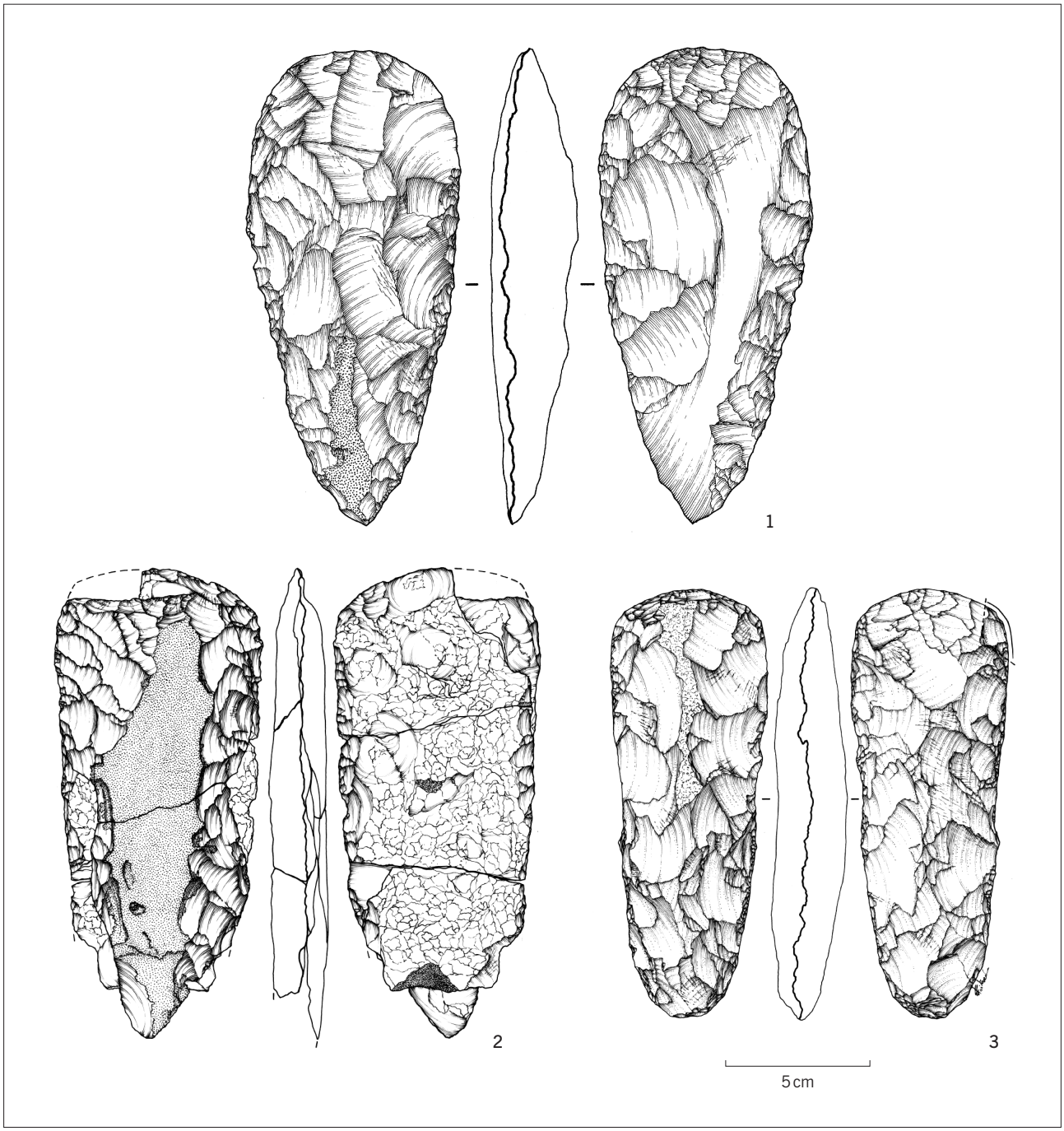


Fig. 8 Roughouts axes made in the flintknapping workshops on the Brie plateau.

Abb. 8 *Ungeschliffene Beilklingen aus den Werkstätten zur Silexbearbeitung in der Brie-Hochebene.*

The morphological specificity of part of the corpus of polished blades in the Marne Valley allows us to make progress in understanding the exchange of these tools in this region. In fact, some of the Bartonian axes products made in the flintknapping workshops on the plateau appear to be standardised, with very flat, easily identifiable quadrangular shapes (cf. Fig. 9,1–2). We should also mention the production of axes of almost identical shape and size at the Jablines flint mine (Bostyn/Lanchon 1992, Fig. 175). Another similar axe comes from a section of the enclosure ditch. This one cannot have been made in the enclosure, as no flintknapping workshops have been recorded in the enclosures of the Lower Marne. When we compare the profiles and cross-sections of the axes made in the workshops on the plateau, in the flint mine and in the enclosure, we note their morphological similarity, which suggests that the polished blade found in the enclosure may have been made in the workshops on the plateau or perhaps in the flint mine. The circulation of finished products from the producer sites to the consumer sites can be seen (Fig. 9,3). The links between mining, settlement, and enclosure can be seen here.

A distinction is made between the bifacial production of the flintknapping workshops in the settlements and that of the workshops in the flint mines. Although both types of

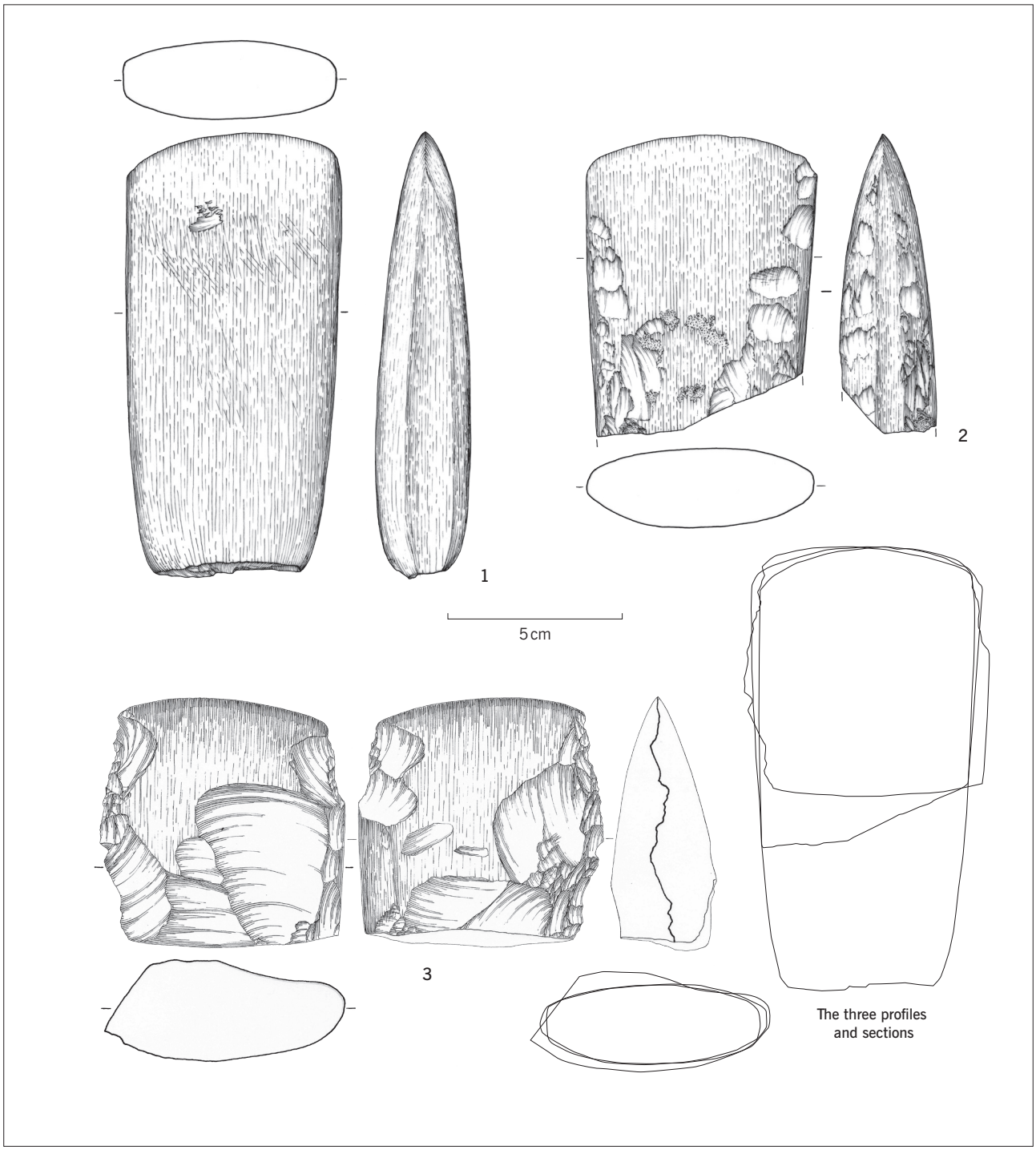


Fig. 9 Polished axes made in flintknapping workshops on the plateau (1–2) and found in the Vignely, Seine-et-Marne department, enclosure (3). No axes are produced within the enclosures.

Abb. 9 *Geschliffene Beilklingen aus den Werkstätten zur Silexbearbeitung in der Brie-Hochebene (1–2) und aus dem Erdwerk von Vignely, Département Seine-et-Marne (3). Innerhalb des Erdwerks wurden keine Beilklingen hergestellt.*

workshop produced trapezoidal axes, the modules produced were different. The village workshops produced axes between 15 and 17 cm long, probably for use in the settlements themselves. Production was probably insufficient to redistribute the surplus. The workshops located in the flint mines produced two types, also trapezoidal, large and small (as we shall see below), probably with the aim of distributing them on a supra-local scale, since the local settlements did not need them, as they produced them themselves.

Comparison with another flint mining centre

When comparing the two flint mining complexes at Jablines (Bostyn/Lanchon 1992) and Spiennes in Belgium (Collet 2012; Collet/Collin 2023), which are less than 200 km apart as the crow flies, we can note that both sites were mined during the Michelsberg period: between 4470/4240 and 3350/2450 cal BC for Petit-Spiennes and between 4230 and 3950 cal BC for Jablines.

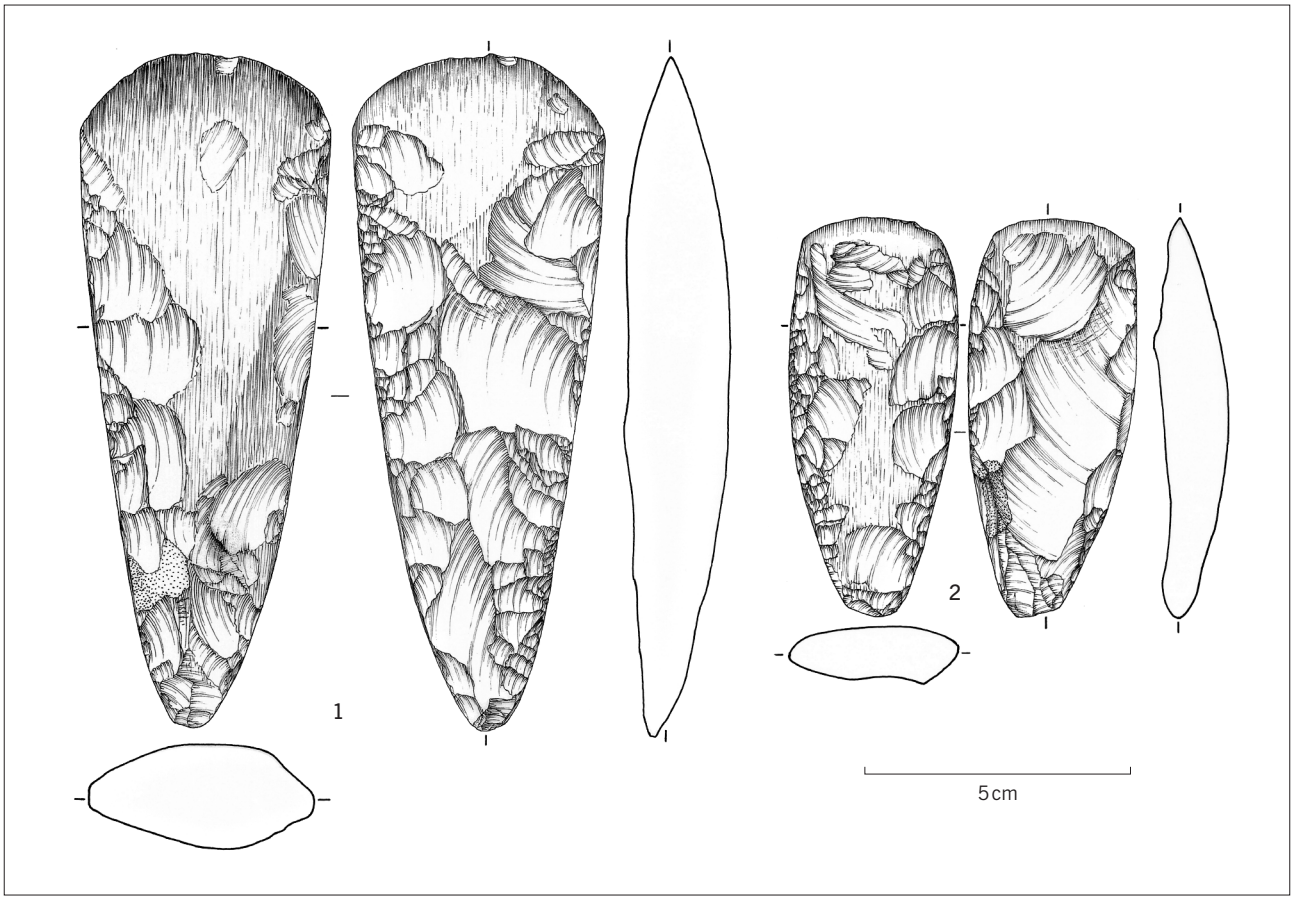


Fig. 10 Cretaceous flint axes from the burial enclosure at Vignely, Seine-et-Marne department.

Abb. 10 *Beilklingen aus kreidezeitlichem Silex aus Bestattungen im Erdwerk von Vignely, Département Seine-et-Marne.*

The main difference lies in the production objectives: In Belgian flint mining, the aim was to obtain both blades and axes, whereas in Jablines it was only axes.

Additionally, there were notable differences in the resulting products. Axes from Petit-Spiennes were classified into three categories based on size: small (7–11 cm), medium (11–18 cm), and large (19–28 cm) (Collet/Collin 2023). At Jablines, there are two types, the smallest measuring between 15 and 17 cm and the largest between 20 and 30 cm (Bostyn/Lanchon 1992).

The organisation of the Michelsberg territory appears to vary significantly between different flint mining complexes. Although the general type of site is consistent – a flint mine located near an enclosure with settlements more or less distant from the mine-enclosure ›pair‹ – the organisation of lithic production exhibits clear differences. At the Michelsberg sites near Spiennes, it is evident that the flint mining products were redistributed between the enclosure and the settlements. The production of axes developed within the enclosure, but not in the settlements. However, the mining products from Jablines were not redistributed to the neighbouring settlements, which were less than 10 km away. Instead, only the raw material was transported in its unworked form, and each settlement developed its own bifacial processing chain. The settlements around Jablines produced axes, which were probably redistributed in very small quantities and transported to the palisaded enclosures. Both mining complexes share a close relationship between the enclosures, settlements, and the extraction site.

Another difference is that the Petit-Spiennes enclosure is probably one of the miners' villages, as it has been found to contain both tools that could be described as »classical for a settlement« and tools and products that are more specific to a flint mining site (axe blanks, picks, and blade cores) (Bostyn/Collet 2011). In the Jablines sector, there is another marked difference, with a third component in addition to the mining-enclosure ›couple‹ that form part of the Michelsberg territorial network, namely, a contemporary necropolis located 800 m from the enclosure. It has the particularity of preserving burials with adult and/or juvenile individuals, whose grave goods consist of polished Bartonian axes (Bostyn et al. 2018). Bostyn proposes the hypothesis that polished or roughened axes were not part of the usual grave goods of Middle Neolithic II burials and that the enclosure was in fact the village of miners or axe-knappers.

The settlements around Spiennes differ from those at the Jablines flint mine in that the enclosures do not have bifacial domestic production; only the settlements develop it. They have a special relationship with flint mining in terms of the raw materials and quantities transported to the flint-knapping workshops in the settlements, and it is possible to establish a special and lasting relationship between them. The relationship between the settlements and the flint mine

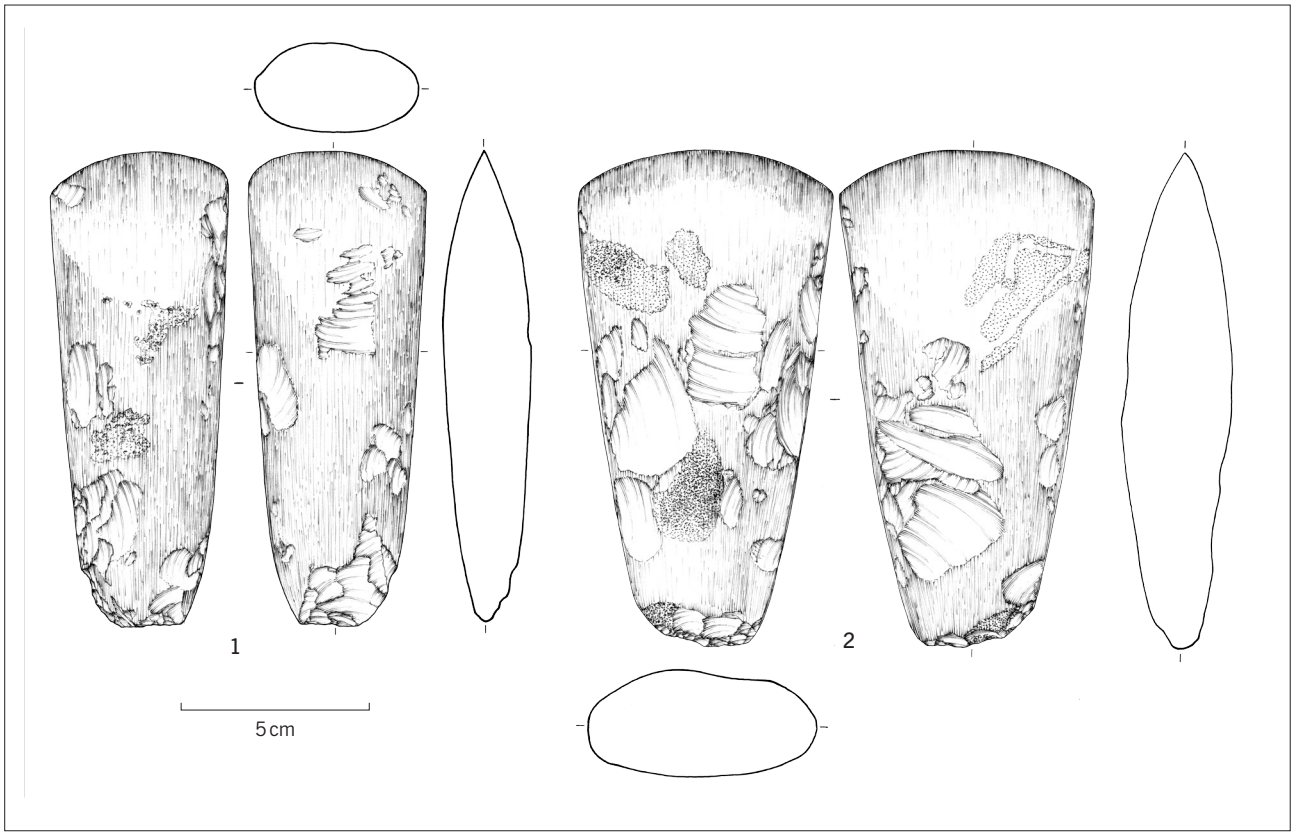


Fig. 11 The deposit of flint axes. 1 local Tertiary Bartonian flint. 2 non-local Cretaceous flint at Méry-sur-Marne, Seine-et-Marne department.

Abb. 11 *Hort von Silexbeilen. 1 lokaler bartonischer Tertiärsilex. 2 nicht lokaler kreidezeitlicher Silex aus Méry-sur-Marne, Département Seine-et-Marne.*

of Jablines is limited to the transport of raw materials. The settlements are autonomous in their lithic production, whether domestic or bifacial. However, there are similarities in the technical methods used when comparing the products from the flint mines of Jablines and those from the flintknapping workshops in the settlements. These similarities include a variety of supports, comparable causes of failure, and comparable shapes. This suggests that the knappers were likely the same and that they remained in the settlements on the plateau. Currently, settlements in the area are only known to exist on the edge of the plateau. None have been discovered in the flint mine or enclosures (the settlement function of the Vignely enclosure is currently under discussion: Brunet et al. in press).

Regarding the distribution of products on a supra-local scale, it is evident at Petit-Spiennes that, as the distance from the flint mining centre increases, imported products decrease and are replaced by specific flint mining products of specialised production, such as blades and axes. This appears to be true for finished products of Bartonian flint. In the case of Petit-Spiennes, such products have been found as far away as the Aisne Valley (approximately 100 km), in the middle Oise Valley (approximately 150 km), and in the Spiere Group (up to 160 km away). Similarly, in the case of Jablines, they have been found more than 200 km to the west and north, but with no known contacts to the Noyen Group in the south-east (Bostyn/Collet 2011; Collet/Collin 2023).

In this way, we can distinguish between production in the flint mines and production in the flintknapping workshops of the settlements. The latter, although specialised, were dedicated to the production of small axes for use in settlements. Each settlement developed its own axe production. In other words, each settlement developed its own family axe production.

Who were the polished axes found in the Jablines mining complex intended for and what were they used for?

We have seen that axes were produced both in the workshops located in the settlements and in the flint mines, thus distinguishing between the family production developed within each settlement and the production developed in the flint mine, whose purpose, as we shall see, was anything but domestic.

Firstly, most of the axes found in settlements were broken (these are axes used by individuals in everyday life) whereas those found in burials were whole; these were pieces of accompanying furniture.

There are several examples of burials in which axes have been laid down. For instance, they are discovered within burial contexts. One burial in the Vignely necropolis contained the remains of a young adult male and a slightly asymmetrical polished Bartonian axe measuring nineteen cm and dated to the early 4th millennium BC. (Bostyn et al. 2018, 295 Fig. 235). In addition, again in the Vignely Necropolis, we have the grave of an immature, c. five-to-eight-year-old child (unfortunately poorly preserved (sex undetermined). The

grave contained three roughouts and a polished axe of poor quality, measuring 15 cm, irregularly shaped, and smaller than those found in the adult graves, all in Bartonian flint (Bostyn et al. 2018, 293 Fig. 232–234).

Flint axes are still being discovered in burial settings within enclosures. One example is the remains of a burial from the Michelsberg enclosure at Vignely. It contained an adult with a pair of Cretaceous flint axes, one measuring 12.9 cm and the other 7.6 cm in length (Fig. 10).

They are still found in the form of deposits in pairs. A deposit was discovered in a ditch at the Michelsberg enclosure in Méry-sur-Marne (cf. Fig. 6,2; Fig. 11). The two axes deposited side by side are made of different materials, combining an axe made in local Bartonian flint (Tertiary formation) (Fig. 11,1) and a second made in Cretaceous flint (Fig. 11,2) found more than 50 km from the Marne Valley, for example in the Northern Chassean (cf. Fig. 4).

The large axes produced in flint mines were not used in settlements or deposited in tombs, as we have just seen, but were probably intended for distribution.

Discussions

What was the purpose of producing large and small axes in flint mines, and small axes in family flintknapping workshops? How were they used locally and on a supra-local scale?

Manufacture and use locally:

For daily life: In answer to the question of the status of small axes, we would say that they are tools intended for use by the community for everyday tasks.

Otherness: The deposit of two whole polished axes, one in Bartonian and the other in Cretaceous flint, suggests otherness as well as the perception of the ›other‹ in its difference; there is a sense of »otherness« attached to the juxtaposition of two flints of different colours, belonging to two different cultures.

Beyond death: To recall the probable link between individuals and their knapping activity? Axes are not part of the usual gave goods; Bostyn suggests that the hypothesis of a link between the individuals buried in the necropolis and the mining and/or knapping activities is based on the fact that, for the same chronological horizon, only the burials in this geographical sector produced this type of funerary material (Bostyn 2018; Bostyn et al. 2018).

Manufacture and use on a supra-local scale: It is unlikely that small axes from the flint-mining industry had an economic role, since they were not distributed to neighbouring settlements, which made their own axes. The theory that large axes were distributed in pairs with smaller ones, favouring the opposition system during the 5th millennium BC, appears entirely plausible to us. It likely refers to the use of paired axes discovered in the European Neolithic period. These axes played a significant role in the fundamental relationship with otherness, where divine twins and mirror effects were driving forces shaping the world, possibly even at its origin (Cassen et al. 2000; Cassen 2012, 1318; 1341). Pairs could also be interpreted as a symbol of a past alliance between two groups who used polished axes for traditional matrimonial payments or to restore old alliances and resume mutually beneficial exchanges (Pétrequin/Pétrequin 1990[6]). Indeed, there are numerous examples of symbolic deposits in pairs[7].

In order to seal alliances: The deposition of two axes in a ditch segment of an enclosure seems to illustrate an alliance. One aim of producing and exchanging high-value goods is to establish alliances and enhance interdependence to avoid conflicts (Keeley 1996). The process of Neolithic groups integrating through exchange can be illustrated by the following example (Perlès 2007, 60). This process is also suggested by the deposit of whole axes discovered in one of the enclosures in the Marne Valley, mentioned above. In this way, the duality on display suggests otherness – the recognition of the other in its difference; there is a sense of »otherness« attached to the juxtaposition of two flints of different colours, belonging to two different cultures.

Otherness, the prospect of recognising the other, is evident in the selection of objects to be exhibited or exchanged, as well as in the range of colours offered by each raw material. During the Neolithic period, this involved conforming to the way the world worked, in one case by exchanging a pair of axe blades of different sizes, for example from Jablines, and in another by exchanging a pair of axe blades of different colours, or different materials. It is as though we can see a hidden aesthetic meaning and order behind the lithic industry (Taçon 1991).

So why are axes in circulation? By circulating them, axes – linked as prestigious and socially valued goods – become a vector for social or cultural cohesion or competition (Pétrequin/Pétrequin 1993); indeed, they were likely chosen as prestige goods to serve as a medium for social interaction (Pétrequin et al. 2002; Pétrequin et al. 2012a; Perlès 2012, 544). Thus, both the utilitarian axe and the high-value axe are part of a system of imaginary signs. Whatever the reason, they are deeply linked to Neolithic beliefs.

On a supra-local scale, axes transmit memorial information (de Weyer/Pérez 2019) by means of a given message that is based on their symbolic shape. While the purpose of large axes is ostentatious, everyday tools are like replicas of the initial message of the meaning given by Neolithic people to their tools (Simondon 1989; Simondon 2006). The lithic economy is not detached from the symbolic systems of the Neolithic period; rather, it is deeply imbued with them (Perlès 2009).

6 <https://www.canal-u.tv/chaines/cerimes/films-du-crava-archeologie-ethnologie/ormu-wari-la-hache-d-echange-en-nouvelle> (04.04.2024).

7 Pétrequin et al. 2002; Thirault 2004; Pétrequin et al. 2008, 330; Pétrequin et al. 2011; Pétrequin et al. 2012; Pétrequin 2012; Cassen 2012, 1318; 1320; 1341–1345; Gauthier/Pétrequin 2017.

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Source of figures

1–2 author; base map V. Brunet, Inrap, BRGM harmonised geolgical map
3 author; base map harmonised geological map (BRGM), 5 m isohypse (IGN BD ® ALTI 25 m)
4 map after Cayol and Colas et al. 2016; CAD: I. Praud; author
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The Iberian Peninsula during the green-axe Neolithic craze

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Zusammenfassung

Die Iberische Halbinsel während der neolithischen Jadebeil-Manie

Die iberische Halbinsel galt in der Vergangenheit oft als Randbereich in den Verteilungskreisläufen alpiner Beile, die sich während des Neolithikums über weite Teile Europas verbreiteten. Wie die Katalogisierung der Beile im Rahmen der JADE-Projekte ergeben hat, war Iberien zwar durchaus ein Randgebiet innerhalb des alpinen Phänomens, jedoch nicht von diesen Kreisläufen ausgeschlossen.

Dieser Beitrag präsentiert den aktuellen Kenntnisstand zu den Merkmalen des alpinen Phänomens auf der Iberischen Halbinsel. Um die Einschränkungen durch den Mangel an zuverlässigen archäologischen Kontexten auszutarieren, beachten wir Chronologie, Verbreitungswege und Nutzung der Beile durch iberische Gruppen.

Schlagwörter Geschliffene Steinäxte, Iberien, Neolithikum, Alpin, Jadeit

Summary

The Iberian Peninsula has traditionally been considered a region on the margins of the distribution circuits of Alpine axes that spread across much of Europe during the Neolithic. However, the cataloguing efforts undertaken during the JADE projects have certified that, although it was a peripheral territory within the Alpine phenomenon, Iberia would not have been excluded from them.

In this work, we offer a synthesis of the current knowledge on the characteristics of the Alpine phenomenon in the Iberian Peninsula. To overcome the limitations imposed by the scarcity of reliable archaeological contexts, we consider their chronology, means of distribution, and use among Iberian groups.

Keywords Ground-stone axes, Iberia, Neolithic, Alpine, Jadeitite

1. Introduction

As elsewhere in Europe, the presence of polished axes in the Iberian Peninsula became widespread from the early stages of the Neolithic. Consequently, the occurrence of ground-stone blades is relatively frequent in Early Neolithic contexts dating back to the mid-6th millennium BC. In subsequent phases, particularly from the Middle Neolithic onwards, these artefacts grow more abundant in both domestic and funerary or ritual contexts[1], persisting until their drastic reduction – albeit not complete disappearance – in the archaeological record during the Early and, especially, Late Bronze Age.

To meet the increasing demand for such artefacts, Neolithic communities in the Iberian Peninsula exploited a wide range of raw materials, including – among others – amphibolite, fibrolite, dolerite, hornfels, and ophite[2]. The production of some of these axes may have reached significant levels of intensity, with the resulting production being distributed sometimes over hundreds of kilometres (Risch 2011; Lozano Rodríguez et al. 2018; Domínguez Bella/López Quintana 2015).

Nevertheless, these communities also demonstrated their ability to acquire polished artefacts originating from outside the Iberian Peninsula. This is exemplified by the case of some hornfels or – maybe – actinolite items (Cassen et al. 2019) and by the extraordinary find of a flint axe discovered at the La Somá site, Andalucía, that allegedly came from the Jutland Peninsula or Southern Scandinavia (Morgado et al. 2014). While of variable quantitative importance, other objects or raw materials such as variscite and amber beads or flint and obsidian blades (Murillo-Barroso et al. 2023; Borrell/Bosch 2012; Vaquer et al. 2012) further indicate the existence of exchange networks between both sides of the Pyrenees.

Although the total number of Alpine axes found in Iberia is not comparable to those recovered in other Western areas, the sum is large enough to deserve consideration as to the integration, however peripheral, of prehistoric Iberia into the major exchange networks that connected other European regions. Already A. Damour and H. Fischer (1878) mention the existence of axes on the coast of Galicia (north-west Spain), although noting the lack of certainty about the type of raw material they were made of. Almost a century later,

1 Orozco-Köhler 2000; Fábregas Valcarce 1990; Carrión Méndez 1985; Pérez Rodríguez et al. 1998; Masclans Latorre 2017.

2 Lillios 1997; Harrison/Orozco Köhler 2001; Risch/Martínez Fernández 2008; García González 2014.

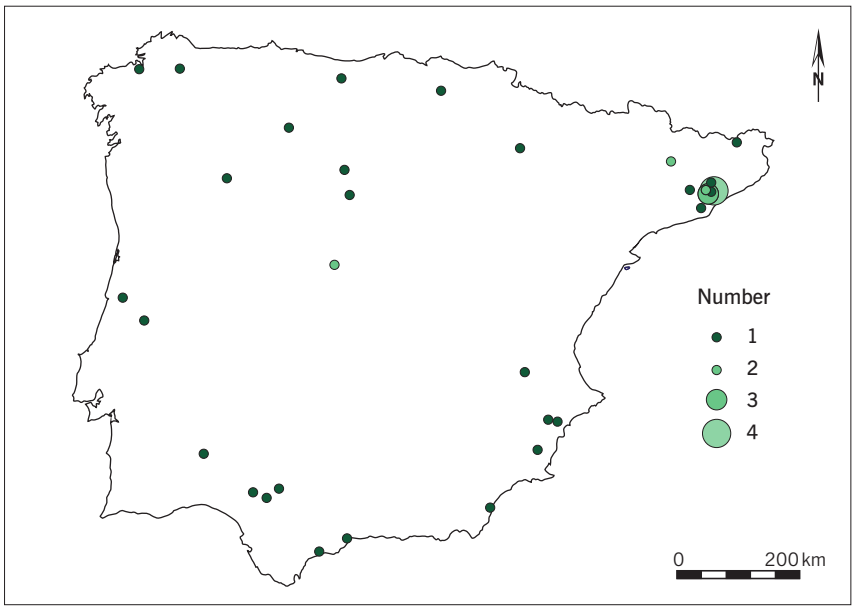

Fig. 1 Distribution of the axes of potential Alpine origin documented so far in the Iberian Peninsula.

Abb. 1 *Verbreitung der bisher von der Iberischen Halbinsel bekannten Beile, die vermutlich aus den Alpen stammen.*

Spain and Portugal still constituted a void in terms of Alpine artefacts, unlike France, Germany, the United Kingdom, and even Ireland (Smith 1965).

It would not be until the early works on Alpine axes by P. Pétrequin and colleagues (Pétrequin et al. 1997; Pétrequin et al. 1998; Pétrequin et al. 2007) that Iberian pieces began to occur in the European inventory of those objects, although a significant portion of them were confined to the present-day territory of Catalonia (north-east Iberia). Beyond the Catalonian territory, the possible presence of Alpine axes was sporadically suggested, such as in the case of Sádaba (Aragón), Peñamellera (Asturias), and Vilapedre (Galicia; Pétrequin et al. 1998; Fábregas Valcarce/Vázquez Varela 1982; Cassen/Vaquero Lastres 2003).

2. The JADE projects: Qualifying and quantifying the presence of Alpine axes in the Iberian Peninsula

The above-mentioned situation underwent a significant transformation in the wake of the research activities linked to the JADE projects »Inégalités sociales et espace européen au Néolithique: la circulation des grandes haches en jades alpins« (2007–2009) and JADE 2 »Interprétations sociales des objets-signes en jades alpins dans l'Europe néolithique« (2013–2019). In the framework of these investigative undertakings, we composed an inventory of polished axes of potential Alpine origin stored in museums and collections throughout the Iberian Peninsula, only leaving aside Catalonia. Given the vast expanse of the area to be covered (more than half a million km^2), the Iberian territory was divided into two roughly equal halves. The northern part was surveyed during the initial JADE project, while the southern half was the focus of the subsequent project.

The outcome of this decade-long endeavour led to a substantial shift in the understanding of the Alpine phenomenon in the Iberian Peninsula. A comprehensive catalogue was compiled, amounting to 46 pieces[3] of presumed Alpine origin. Although still predominantly concentrated in the Catalonian territory, these artefacts were now dispersed across the entire Peninsula (Fig. 1).

In terms of typology, these axes display a considerable diversity. The most abundant type in the Iberian catalogue is the Durrington »gotte-d'eau« (15; 32.6 %), followed by the Puy (14; 30.4 %). The other typologies (Chelles, Begude, Pauilhac, Tumiac, etc.) trailing at a considerable distance (Fig. 2).

Such typological distribution is quite consistent with the dynamics observed in other parts of Europe (Pétrequin et al. 2012). Thus, most of the artefacts found in the Iberian Peninsula correspond to what can be considered »later« types, aligning themselves with the fourth and fifth periods of the Alpine phenomenon as defined by Pétrequin (from the second half of the 5th millennium onwards). Additionally, these are models that either exhibit a ubiquitous distribution throughout Western Europe (Durrington, Puy, Chelles) or are distinctly southern (Bégude, Pauilhac). Unsurprisingly, there is also a residual presence of Carnacean types originating from Brittany (Tumiac; Fig. 3).

The geographical distribution of the main types across the Iberian Peninsula does not exhibit clear regularities, probably due to the limited sample size (Fig. 4). The sole exception might be a potential tendency for Durrington-type axes to display a more western distribution, in contrast to Puy axes, whose circulation appears to be more restricted, particularly to the eastern part, and notably along the Mediterranean arc. Otherwise, there is a notable presence of Chelles-type axes in the Catalonian territory, and – on a lesser scale – Pauilhac-type axes in the upper course of the Ebro River and the surrounding areas of the Cantabrian Mountains.

3 Since the initial draft of this work, a new potential alpine axe has been discovered in the province of Granada (Andalucía). Future analytical research may confirm such origin.

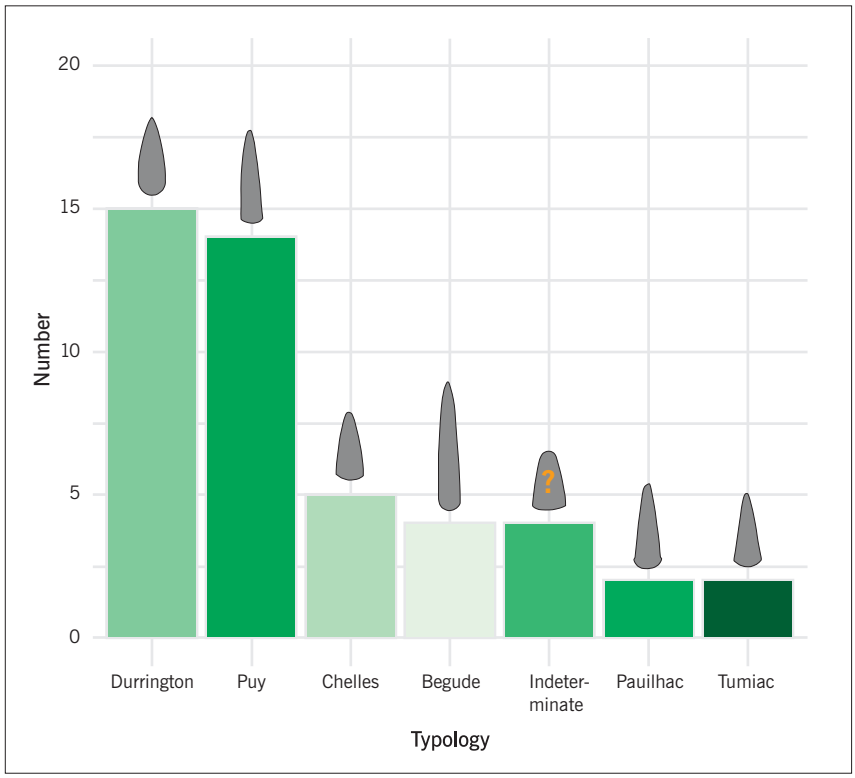

Fig. 2 Typological classification of axes of potential Alpine origin documented in the Iberian Peninsula.

Abb. 2 *Typologie der auf der Iberischen Halbinsel gefundenen und vermutlich aus den Alpen stammenden Beile.*

The lack of contextual information prevents the establishment of a reliable archaeological framework for many of these artefacts and, therefore, makes it challenging to determine whether there is more than mere coincidence behind these apparent differences in the geographical distribution. However, as we shall see later (section 3.3), the distribution of some of these axes can be interpreted in the light of the spatial dynamics observed north of the Pyrenees.

3. Limitations on our knowledge regarding the Alpine axes in Iberia

As said before, a strong limitation in our understanding of the Iberian axes of alleged Alpine origin is due to the fact that, for the most part, they lack a reliable archaeological context. Nearly 70 % of the items (67.4 %) correspond to isolated finds, for which either no information about their original context is available or their origin has been traced to some extent but still carries a significant degree of uncertainty (Lantes-Suárez et al. 2021; Rodríguez Rellán et al. 2022).

If we focus on specimens that have indeed been recovered in archaeological contexts, they are predominantly associated with tombs, specifically pit burials (26.1 %), such as those of Can Gambùs 1 or Bòbila Madurell, both Catalonia (Vaquer et al. 2012; Roig et al. 2010; Masclans Latorre 2017). There are also artefacts in peculiar contexts, such as within a burial in one of the galleries of the variscite mines of Can Badosa, in Gavà, Catalonia (Borrell/Bosch 2012). Additionally there are a few examples of potential Alpine axes found in domestic contexts, such as in Gatas, Andalucía.

Once again, the geographical distribution of the Alpine axes for which reliable contexts are available is seriously lopsided, with almost 90 % of them (86.6 %) located in Catalonia (Fig. 5; Tab. 1). This offers some indication of the challenges posed by the meagre data available when investigating the phenomenon of Alpine axes in the Iberian Peninsula.

3.1 Does green mean Alpine?

In this study, we refer to »axes of potential Alpine origin«. This is because only a portion of the items for which such an origin is suspected has been analytically provenanced: Just 26 axes out of the 46 potential candidates (56.5 %) have undergone analysis. Most of them (24; 92.3 %) were subjected to spectrometry, while the remaining samples were examined using various techniques such as RAMAN, XRD, or SEM EDX, among others. Most of these analyses were conducted within the framework of the JADE projects, although some of them were carried out by other researchers (Odriozola Lloret et al. 2015; Odriozola Lloret et al. 2016; Villalobos García/Odriozola 2017). Regarding the axes themselves, these analysed artefacts exhibit an uneven geographical distribution (Fig. 6), with a significant number of them located in Catalonia.

The analyses showed that the axes were predominantly crafted from jadeitite (50.0 %), followed, at a considerable distance, by eclogite (26.9 %) and omphacitite (7.6 %). Among the pieces for which a geological provenance has been proposed, those from the Viso group stand out (53.8 %), followed by those from the Voltri (15.4 %) and Revello (3.8 %) groups. However, it has not been possible to determine with certainty the geological origin of six of the items analysed.

Fig. 3 Some examples of potential Alpine axes found in the Iberian Peninsula. 1 Museo Arqueológico Nacional; 2 Palencia; 3 Ávila; 4 Bragança; 5 Elviña; 6 El Pedroso; 7 Sádaba; 8 Dima; 9 Vilapedre; 10 Cangas-type axe from Vilalba made on sillimanite.

Abb. 3 *Einige Beispiele für Beile, die auf der Iberischen Halbinsel gefunden wurden und vermutlich alpinen Ursprungs sind. 1 Museo Arqueológico Nacional; 2 Palencia; 3 Ávila; 4 Bragança; 5 Elviña; 6 El Pedroso; 7 Sádaba; 8 Dima; 9 Vilapedre; 10 Beil vom Typ Cangas aus Vilalba, hergestellt aus Sillimanit.*

The inability to certify – beyond reasonable doubt – the geological origin of a significant portion of the green axes found in the Iberian Peninsula (56.5 %), coupled with the absence of secure archaeological contexts for a considerable number of these pieces, makes it risky to uncritically assume their Alpine origin. This is true even for those items whose analysis has identified them as being made of rocks like jadeitite, omphacitite, or eclogite. Such risk arises from two main scenarios: 1) the uncertainties as to the moment of arrival of the pieces in the Iberian Peninsula, which would not preclude their arrival in modern times; 2) the difficulty in ruling out a regional origin.

Regarding the first problem, the aesthetic quality of many Alpine axes would have made them highly appealing for scholars and collectors, especially from the 17th century onward. For Portugal and Spain, given the colonial past of these nations, there is the added risk that some of these axes may have come from America. Thus, many Taino pieces share a teardrop-shaped morphology that can make them difficult to distinguish from Alpine productions like the Durrington »gotte-d'eau« (precisely the most numerous in the Iberian Peninsula).

An illustrative example of this risk is the collection of jadeite axes held at the Museo Canario (Las Palmas de Gran Canaria). These axes were first presented at an international congress in Lille (France) in 1874 as originating from the first Neolithic communities to arrive on the island. Almost a century later, in 1963, a new study went further and proposed an Alpine origin for these pieces. However, a careful historiographical and document review conducted earlier in this century (Farrujía de la Rosa/Arco Aguilar 2004) established that their actual origin was Puerto Rico.

This example serves as a cautionary tale about the danger of uncritically assigning an Alpine origin to axes based on

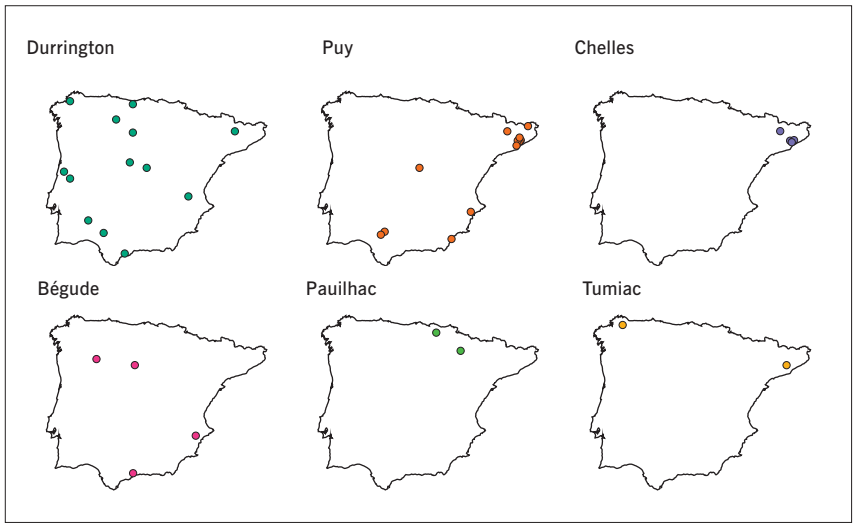

Fig. 4 Geographical distribution of the main types of axes on the Iberian Peninsula of potential Alpine origin.

Abb. 4 *Geografische Verbreitung der wichtigsten Beiltypen auf der Iberischen Halbinsel mit möglicherweise alpinem Ursprung.*

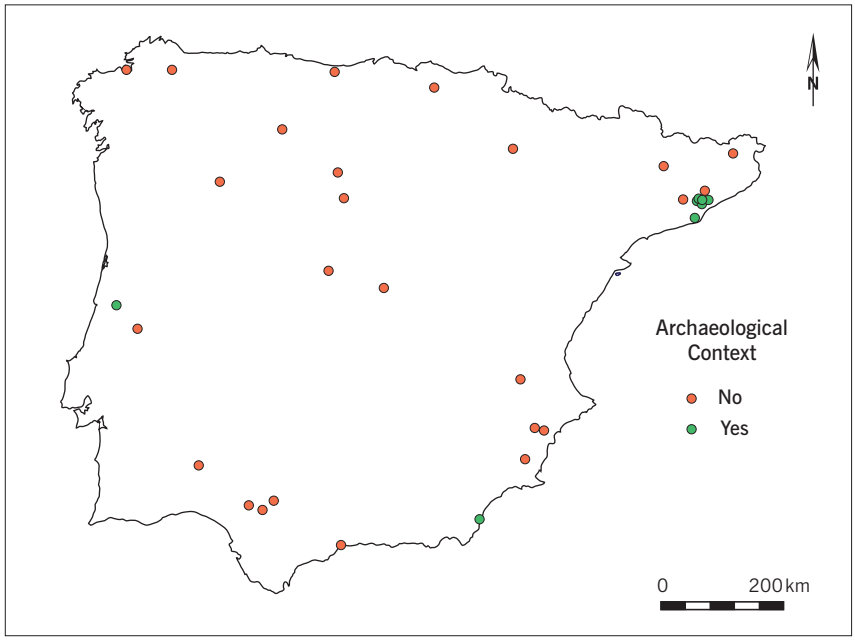

Fig. 5 Axes analysed in this paper, recovered in a secure archaeological context.

Abb. 5 *Wissensstand über den gesicherten oder ungesicherten archäologischen Befund der in diesem Beitrag behandelten Beile. No ungesichert; Yes gesichert.*

their shape, colour, or even raw material. This is especially true for the items lacking any archaeological context. In such cases, archaeological and analytical research must necessarily be accompanied by the analysis of historical documentation (see Lantes-Suárez et al. 2021; Rodríguez Rellán et al. 2022) to rule out – as far as possible – the risk that these pieces were brought to the Iberian Peninsula in modern times.

The second problem lies in the inability to determine whether some of the »Alpine« items were, in fact, made from raw materials originating from the Iberian Peninsula. This is particularly true for axes made from eclogite. Recent research has identified the exploitation of eclogites from the Sierra de Baza, Granada (Andalucía), to produce polished axes during a period ranging from the Early Neolithic to the Bronze Age (Lozano Rodríguez et al. 2018). Furthermore, archaeometric analysis has revealed that many of the eclogite axes from Baza would have been distributed across hundreds of kilometres within the south and east of the Iberian Peninsula. The presence of other significant sources of eclogite (e.g., Extremadura and Galicia) that could have been exploited in prehistoric times makes it advisable to exercise extreme caution when dealing with eclogite axes whose petrographic or geochemical analyses have inconclusively linked them to geological sources in the Alps.

3.2. When did Alpine axes arrive in the Iberian Peninsula?

As mentioned in the preceding pages, most artefacts with a potential (or confirmed) Alpine origin found in Spain and Portugal correspond to typologies that are predominantly late within the Alpine phenomenon. This is the case for the most numerous pieces – such as the Durrington »gotted'eau« or the Puy – but also for some of the less represented types, such as the Pauilhac or the Tumiac. All of these circulate from the second half of the 5th millennium BC and persist until well into the 4th millennium BC (Pétrequin et al. 2012). Other artefacts present in the Peninsula, such as the Chelles-type axes, have a somewhat older origin (mid-5th

Country	Region	Alpine axes
Spain	Catalunya	19
	Andalucia	7
	Castilla y León	5
	Madrid	3*
	Galicia	2
	Com. Valenciana	2
	Aragón	1
	Asturias	1
Portugal	Bragança	1
	Castelo Branco	1

Tab. 1 Number of axes of potential or confirmed Alpine origin discovered in various regions of Spain and Portugal. *Please note that the figures from Madrid should be interpreted with caution, as they include axes deposited in the Museo Arqueológico Nacional, whose origins in the region are not definitively established.

Tab. 1 *Anzahl der Beile mit möglicher oder bestätigter alpiner Herkunft, die in verschiedenen Regionen Spaniens und Portugals gefunden wurden. * Es ist zu berücksichtigen, dass die Zahlen aus Madrid mit Vorsicht zu genießen sind, da sie Beile aus dem Museo Arqueológico Nacional enthalten, deren Fundorte in der Region nicht gesichert sind.*

millennium BC), but their extended duration (until the 4th millennium BC) results in the chronology of their arrival not necessarily differing from that of later productions.

The scarcity of reliable archaeological contexts does not help in establishing the specific chronology of the arrival of Alpine axes in the Iberian Peninsula. Once again, we must draw upon the few examples where we have reliable information about the circumstances in which they were found. In this regard, the information primarily comes from two specific areas: the north-east (Catalonia) and – to a much lesser extent – the north-west (Galicia and northern Portugal).

Regarding the first region, as previously mentioned, almost all pieces of potentially Alpine origin found *in situ* come from funerary contexts, specifically pit burials (Bòbila Madurell, Bòbila d'en Joca, Bòbila Padró, Bòbila Bellsolà, Can Gambús 1) or burials in reused mining galleries (Can Badosa). There are radiocarbon dates for some of these specific contexts: This is the case for M5 at Bòbila Madurell (Ly-10583: 5105 ± 30 BP, 3974–3800 cal BC), for E-70 and E-162 at Can Gambùs 1 (CNA-2293: 5065 ± 45 BP, 3966–3714 cal BC; CNA-2269: 4982 ± 44 BP, 3942–3648 cal BC), for M83 at Can Badosa (Beta-155686: 5222 ± 110 BP, 4328–3789 cal BC), and for Bòbila Padró (OxA-8776: 4600 ± 70 BP, 3529–3094 cal BC).

Apart from Bòbila Padró, a date that has been labelled as unusually recent considering the type of structure and grave goods it contains (Vaquer et al. 2012), the rest of the dates clearly point to a deposition of Alpine axes between the late 5th millennium and, especially, the first third of the 4th millennium BC. The same impression is obtained when extending the scale to contexts like those in which axes of potential Alpine origin have been recovered (Fig. 7).

As for the north-west of the Iberian Peninsula, two of the axes found there – although originally without clear context – have been reasonably linked to megalithic burials (Lantes-Suárez et al. 2021; Rodríguez Rellán et al. 2022). While we lack radiocarbon dates for those specific contexts, we do have them for some others in the region (Fig. 7). The summed probability distribution of the available dates suggests a long existence of these monuments, with dates concentrating around two specific points in time: 4300 cal BC – likely coinciding with the initial construction phase in the region – and 3700 cal BC, probably linked to the onset of the construction of the first passage graves. Either of these two peaks suggests an intensification of construction activity in the region that is at times coeval to those when Catalonia might have been receiving Alpine axes. Therefore, it cannot be ruled out that it was precisely during these periods that Alpine pieces also reached the north-west.

Indirect evidence of the arrival of Alpine artefacts in the Iberian Peninsula may be inferred through the presence of axes generally considered as potential imitations of Alpine

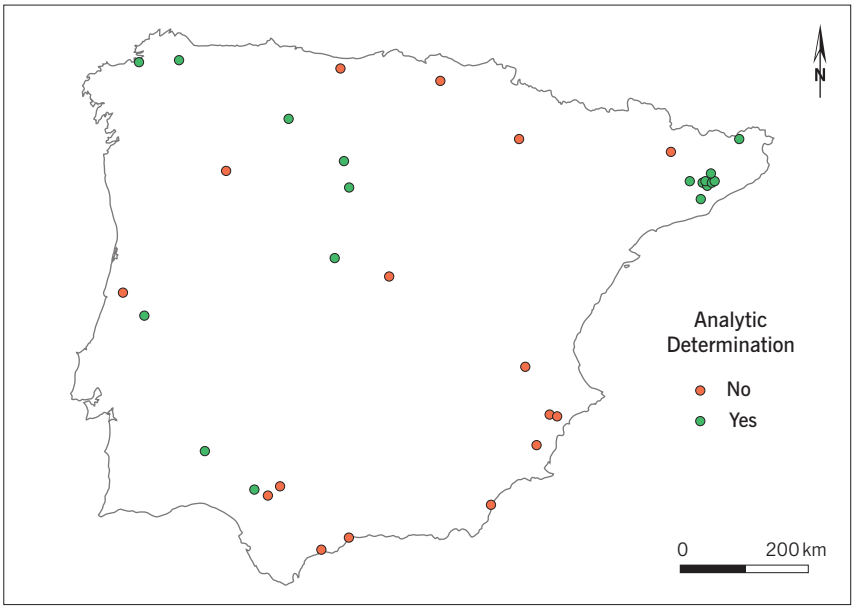

Fig. 6 Axes of potential Alpine origin that have undergone geochemical analysis.

Abb. 6 *Geochemisch analysierte Beile mit möglicherweise alpinem Ursprung. (No) nicht bestimmt; (Yes) bestimmt.*

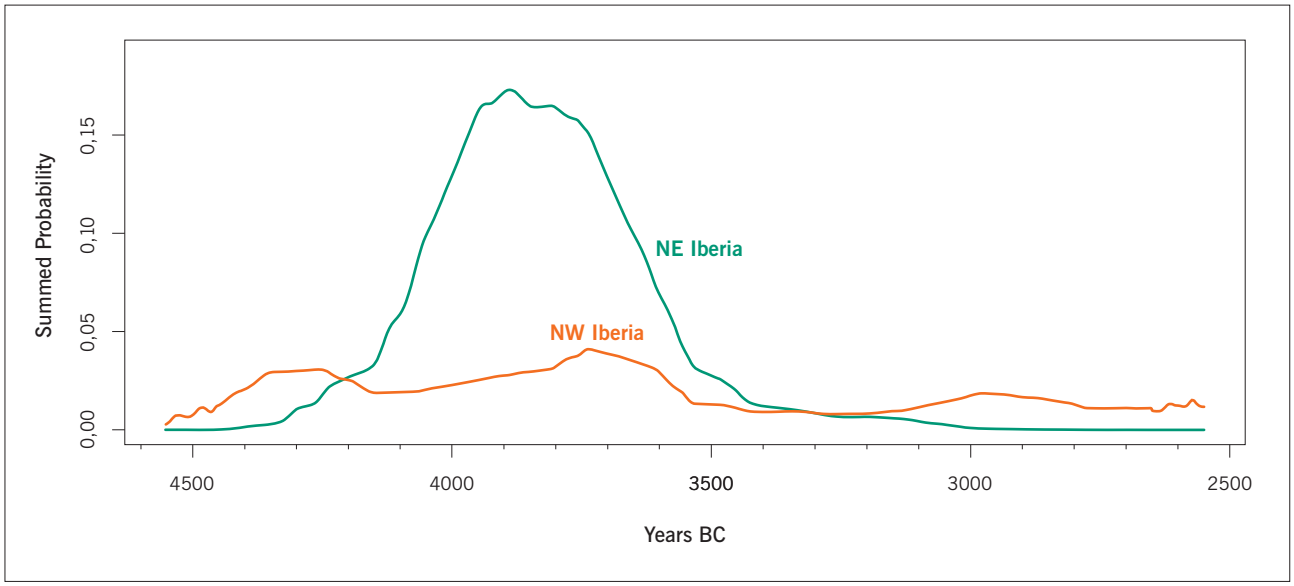

Fig. 7 Summed Probability distribution of 144 radiocarbon dates available for Iberian sites akin to those where axes of potential Alpine origin have been found.

Abb. 7 *Addierte Wahrscheinlichkeitsverteilung von 144 Radiokarbondatierungen von Iberischen Fundorten, die denjenigen ähneln, an denen vermutlich alpine Beile gefunden wurden.*

models. Perhaps the most well-known case is that of the so-called »Cangas« type axes, typically crafted from fibrolite and regarded as imitations of perforated Tumiac axes made from Alpine rocks (Pétrequin et al. 2012; Fábregas Valcarce et al. 2012). The Cangas axes not only exhibit clear morphometric similarities with their Breton counterparts but also feature a perforation in their proximal part (Fig. 3,9–10).

Their distribution, mainly limited to the western Iberian Peninsula, is associated with megalithic monuments such as the Dolmen de Santa Cruz, Asturias, or Dehesa de Río Fortes (Ávila, Castilla y León). For the latter, heavily altered, a radiocarbon date is available using material from a burned layer linked to the closure of the monument's initial phase (Beta-164477: 4970 ± 80 BP, 3951–3638 cal BC; Fabián García 2006). While the monument's state of preservation does guarantee that the Cangas-type axe belonged to this early phase, it is noteworthy that this would be quite similar to the Catalonian pit burial contexts where Alpine axes were retrieved.

In recent years, a new Cangas-type axe made of sillimanite has been recovered at the Arroyo Saladillo site (Málaga, Andalucía), near the monumental tombs of Antequera (Fernández Rodríguez et al. 2014; García Sanjuán et al. 2020). This site comprised over a hundred pits, a 34-meter-long trench, and several burials under tumuli, one of them defined as »proto-megalithic.« The structure where the axe was found (S.102) consisted of an oval-shaped tumulus or small cairn, just over 1 m in diameter, covering a layer of stones sprinkled with ochre, on top of which the axe was the only element deposited.

Although we lack numerical dates for the structure where the axe was found, there are several from other structures at the same site. Of particular interest is S.94, a »proto-megalithic« burial consisting of an oval cairn with a diameter of 2.6 m, beneath which two large slabs acting as some sort of »capstones« were documented. Under these slabs, the remains of a young adult were found. Radiocarbon dating on the human remains (CNA-3336: 5137 ± 32 BP) indicates an age of 4039–3804 cal BC.

Interestingly, the feature where the axe was found seems to be part of a group of structures composed of S.94 and two other burials under tumuli (S.90 and S.95) that were structurally and conceptually very similar to each other. In fact, the excavators suggest that S. 102 – despite not preserving human remains inside – might have functioned as a »burial« in which the axe could have symbolically replaced the interred individual (Fernández Rodríguez et al. 2014).

These four structures formed an alignment in the south-east–north-west direction, almost parallel to the ditch. The Bayesian analyses of the radiocarbon dates (García Sanjuán et al. 2020) suggest that the infilling of the ditch would have begun sometime between 3870 and 3670 cal BC. Likewise, these same models suggest that the construction of structure S.94 would have taken place before the initiation of the ditch infilling. By extension, this is also likely true for the other three structures beneath tumuli nearby, including S.102, where the perforated Cangas-type axe was recovered.

Therefore, in conclusion, there is considerable evidence suggesting that the sillimanite axe at Arroyo Saladillo was deposited in structure S.102 sometime between the late 5th millennium BC and the first third of the 4th millennium BC. Again, these dates roughly coincide with those of Alpine axes in Catalonian contexts and, perhaps, with the last depositions of Alpine Tumiac axes in French sites (Pétrequin et al. 2012).

Despite the available data for the Iberian Peninsula suggesting that a significant portion of axes of potential Alpine origin probably arrived at some point in the late 5th millennium BC, but even more likely in the first half of the 4th millennium BC, it should be noted that the arrival of pieces in both earlier and later moments cannot be ruled out.

Thus, the marginal presence of Bégude-type axes (4) points precisely towards earlier dates. These are the oldest

axe types produced in the Alps, appearing in the record between 5300–5200 BC and vanishing no later than the mid-5th millennium BC (Pétrequin et al. 2012). The fact is that these dates are early for some areas of the western half of the Iberian Peninsula, as they precede the development of the megalithic architecture and even the advent of the farming economy itself.

The presence of some of these axes in the vicinity of the variscite sources in Palazuelo de las Cuevas, Zamora (Castilla y León; Fig. 4), may suggest their arrival as a result of early contacts stemming from the exchange of variscite beads. Notably, the presence of green beads from Palazuelo has been documented in Breton monuments around these dates (Querré et al. 2019). However, this possibility collides with the local archaeological record, which suggests that the exploitation of variscite in north-western Iberia would have been seemingly anecdotal until well into the 4th millennium BC (Rodríguez Rellán et al. 2019). Since the deposition chronology for these Bégude axes is unknown, as they lack any archaeological context, it should not be ruled out that they may have arrived in the region at a later date, perhaps after circulating or even being hoarded over generations.

This process might also explain the presence of axes of potential Alpine origin in contexts with seemingly later chronologies. Such is the case, for example, of Gatas (Almería), where an axe has been recovered in a domestic site dating back to the early 3rd millennium BC (Fábregas Valcarce et al. 2017).

3.3 How did green axes arrive and how did they spread throughout Iberia?

The limited number of artefacts of potential Alpine origin, coupled with the uncertain archaeological context of most of them, makes it necessary to consider carefully all the conclusions derived from their spatial analysis. This circumstance renders it exceedingly challenging to speculate on both the routes of penetration and their subsequent distribution throughout the entire Iberian Peninsula.

It appears evident that one of the primary penetration routes for Alpine products into the Iberian Peninsula was along the north-eastern coast. The extensive networks of trade involving variscite, salt, honey-flint, or obsidian, among other commodities (Borrell/Bosch 2012; Vaquer et al. 2012), likely facilitated the arrival of these axes in Catalonian territory. It is just possible that this region acted as a redistributive centre for Alpine axes to other parts of the Peninsula, both along the Ebro Valley and the Mediterranean coast.

The question arises as to the existence of other distribution routes for Alpine products into the Peninsula, and, in some cases, the answer may be relatively straightforward. For example, the two Pauilhac-type axes found in Dima (Bizkaia, Basque Country), and Sádaba (Zaragoza, Aragón; Fig. 3–4) may have reached the southern side of the Pyrenees from the French Midi, where there seems to be a significant concentration of these axes (Pétrequin et al. 2012), either bypassing the mountain range along the French-Basque coastal region or through some of the mountain passes used over the centuries, such as Roncesvalles or Ibañeta.

The complex issue lies in determining the existence and/or significance of contacts between Brittany and northern Iberia. The finds of variscite from Palazuelo de las Cuevas and Encinasola (Huelva, Andalucía) in Breton megaliths (Querré et al. 2019) suggest the occurrence of at least sporadic contacts, as indicated also by the testimonial presence of Carnacean axes in Galicia and Catalonia (Fig. 3–4) or by the presumed local imitations of such axes (»Cangas«) all around the western half of the Iberian Peninsula.

From the 1930s onward, the hypothesis of maritime contacts between the Galician and Breton land-ends has been present in the archaeological literature. Alleged similarities in rock art or material culture (Cassen et al. 2012; Cassen et al. 2019) allowed for the extension back to the Neolithic period of contacts which are clearly documented in the Early Bronze Age. However, the virtual absence of Breton axes (especially of the Saint-Michel type) suggests that if these contacts existed, they must have been very sporadic or occasional.

Determining the way these axes circulated once they reached the Peninsula is as challenging as reconstructing how they arrived in the first place. In this regard, the analysis of variscite ornaments, known to coincide temporally and even as part of the same grave goods in contexts both on the Iberian Peninsula and France (Cassen et al. 2012), can serve as a valuable indicator of how the axes themselves might have circulated. In fact, it is not implausible to consider that both objects flowed along the same networks.

The analysis of over 8000 green stone beads across the entire Iberian Peninsula (Rodríguez Rellán et al. 2023) suggests that a significant portion of these green adornments have circulated through straightforward exchange between communities separated by less than a day's journey on foot. The uneven access to green beads and pendants is explained, at least in part, by the strength of connections among these communities within exchange networks.

It is possible, therefore, that the circulation of Alpine axes occurred also through direct exchange between neighbouring communities. This, in turn, could explain the chronological differences of several centuries between the Iberian pieces and some of their counterparts closer to the geological sources. Likewise, the ability of certain groups and individuals to acquire these items may have stemmed from their capacity to play a significant or strategic role within exchange networks.

3.4 For whom were these objects intended?

Once again, the lack of clear archaeological contexts for axes with a potential Alpine origin poses significant challenges in understanding the specific consumption practices of these objects. In other words, it is very difficult to determine who carried and used these pieces and whether their possession was limited to specific groups or individuals within Iberian Neolithic communities.

An examination of the few instances where axes of possible Alpine origin are found in clear contexts, as in the case

of Mine 83 in Gavà or of the four pit burials at Can Gambùs 1 (Roig et al. 2010; Borrell/Bosch 2012), reveals that these pieces tend to appear in individual burials. Data gathered from contexts involving more than 150 excavated tombs in five Catalonian necropolises, where around a dozen axes of possible or confirmed Alpine origin have been recovered, suggest specific consumption patterns for these items (Masclans Latorre 2017). Specifically, Alpine axes seem to be more closely associated with the burials of adult males, where other foreign elements like honey-flint from France or Sardinian obsidian are also recorded. Additionally, they appear to be linked to a specific item – the arrowhead – which has traditionally been considered a strong masculine marker.

In conclusion, the available data for north-eastern Spain suggest that Alpine axes were primarily consumed by adult males who had a certain capacity to mobilize political and economic resources, allowing them access not only to these axes but also to other foreign objects and raw materials. This pattern appears to be similar to that found in other European regions and also in some ethnographic parallels (Pétrequin/Pétrequin 2012), and it suggests that access to Alpine axes would not have been widespread among all members of prehistoric communities but rather limited to those who played a significant role within them (the case of grave 43 in the Varna necropolis being a paradigmatic example). In this regard, gender and age appear to have been crucial factors determining the possibility (and perhaps the right) to carry these items.

Nevertheless, it is important to keep in mind that these data originate from a relatively restricted geographic and chronological context (north-eastern Iberia during the 4th and 5th millennium BC). Therefore, caution should be exercised when assessing their representativeness concerning other regions of the Iberian Peninsula and different prehistoric periods.

4. Conclusions

Barely two decades ago, only a handful of presumably Alpine axes were known in Iberia, nearly half of them coming from Catalonia. The cataloguing task carried out under the auspices of the JADE pan-European research project led to the discovery of about 50 axes that were widely distributed in Spain and Portugal, albeit north-eastern Iberia remained the main cluster of this kind of ground-stone artefacts, particularly in the Catalonian districts of Vallès and Baix Llobregat. Although, at the time of writing this paper, the number of the Alpine axes keeps growing in Iberia, it is no less certain that, in comparison with the numbers reported in other areas of Western Europe, the »green craze« had a limited echo for reasons related not only to the distances and geographic obstacles involved, but also to the choices of an economic and cultural nature on the part of the Iberian prehistoric groups. Nevertheless, in a more restricted way these communities – or, more to the point, sections of these polities – may have been aware of the particular value assigned to the green axes and they may have managed to acquire a number of them or, failing that, to replicate their design in other, more accessible, raw materials such as sillimanite (i.e., the Cangas-type axes) and other metamorphic rocks.

The findings confirm that, despite Iberia's role as a peripheral territory within the distribution circuits of Alpine axes, it did not remain aloof from the »green craze« that affected much of the rest of Europe during the 5th and 4th millennia BC. This contrasts with the perception prevalent in the mainstream of the specialised literature until almost the end of the first decade of the present century.

However, the catalogue of Iberian axes with presumed Alpine origins is not without problems that hinder its interpretation. The main limitation arises from the scarcity of items found in secure archaeological contexts. This circumstance significantly limits the determination of the exact moment when these pieces arrived in the Iberian Peninsula, their penetration routes, their distribution patterns, and whether their consumption was restricted to specific individuals or groups within Iberian Neolithic communities. The lack of secure contexts calls also for additional historical and archaeometric analyses to certify, first, the Alpine origin of the axes, and, second, to rule out their arrival in modern times.

Based on a thorough analysis of the scarce data available, it can be concluded that most of the axes of potential Alpine origin present in the Iberian Peninsula are southern or ubiquitous types with a relatively late chronology within the Alpine phenomenon. These axes likely crossed the Pyrenees from the late 5th millennium onwards and, more probably, the first half of the 4th millennium BC. However, the presence of potentially older types – such as Bégude axes – prevents our ruling out the occurrence of Alpine items as early as the first half of the 5th millennium BC. Similarly, the existence of pieces in late 4th millennium contexts suggest an occasional persistence in the significance of these items until relatively advanced moments of late prehistory.

The geographical distribution of the catalogue strongly suggests that the north-east was the main entry point for Alpine pieces into the Iberian Peninsula, possibly in the framework of exchanges where variscite or honey flint also played a crucial role. Thenceforth, Catalonian centres likely acted as redistributors to other areas of the Peninsula. However, the occasional presence of Carnacean axes also suggests the possible existence of contacts, perhaps by sea, between Brittany and the northern part of the Peninsula.

As we have repeatedly stated in the preceding pages, most of the Alpine finds in Iberia – or, for that matter, elsewhere – lack a minimally secure context, a fact that obviously limits the possibilities of assessing the socioeconomic significance of the jade axes. That said, the intrinsic features of these artefacts (allochthonous provenance, over-polishing, aesthetic values) likely indicate that they were considered as *objects of excellence* and as a highly prized commodity within the sphere of the political economy. In the very few cases where contextual information is at our disposal, the consumption of these items seems to be mainly reserved to adult males, a pattern that, if confirmed by further finds, would be consistent with similar observations made in many sites across Neolithic Europe.

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Edge tool technologies in prehistoric Greece: A short overview of the published data

Danai Chondrou

Zusammenfassung

Schneidwerkzeugtechnologien im prähistorischen Griechenland: Ein kurzer Überblick über die veröffentlichten Daten

Bei »Technologie« handelt es sich in erster Linie um ein soziales Phänomen mit einer komplexen Dynamik. Die Untersuchung von Werkzeugen vergangener Gesellschaften hat daher das Potenzial, technische Traditionen und – durch sie – soziokulturelle Merkmale sichtbar zu machen. Da Schneidwerkzeuge gezielt und aufwändig ausgeformte Artefakte sind, eignen sie sich hervorragend als Gegenstand dieser Forschungsrichtung. Dieser Beitrag untersucht die verfügbaren publizierten Daten verschiedener griechischer Schneidwerkzeugassemblagen aus dem Neolithikum, um unterschiedliche technologische Entwicklungen aufzuzeigen. Anhand des Materialkorpus können gemeinsame Aspekte der Herstellung und Instandhaltung von Werkzeugen (z. B. Präferenzen bei den Rohmaterialien und Arten der Verwendung) auf einer Makroebene durch die Zeit hindurch nachverfolgt werden. Gleichzeitig sprechen signifikante Unterschiede, hauptsächlich in den Herstellungstechniken und der Typologie, jedoch für vielfältige Traditionen der Steinbearbeitung, die, geografisch betrachtet, eine grobe Nord-Süd-Verteilung wiedergeben. Einigen Indizien zufolge scheinen die neolithischen Gemeinschaften Nordgriechenlands im Vergleich zu denen des südlichen Festlandes und der Inseln vor allem balkanorientiert zu sein, was ihre eher komplexen Schneidewerkzeugtechnologien betrifft, die – in einigen Fällen – den Eindruck erwecken, technisch gesehen »einfacher« zu sein.

Schlagwörter Schneidwerkzeug, Neolithikum, Steinzeugtechnologie, Griechenland, technologische Traditionen

Summary

»Technology« constitutes, first and foremost, a social phenomenon with complex dynamics. Therefore, the study of the tools of past societies has the potential to reveal technical traditions and – through them – sociocultural characteristics. Being intentionally and extensively shaped artefacts, edge tools are a prime candidate to serve this line of research. The current paper analyses the available published data from various Greek Neolithic edge tool assemblages, seeking to identify different technological trajectories. Judging from the corpus of material, common aspects in tool manufacture and maintenance (such as raw material preferences and modes of exploitation) can be traced through time on a macro-scale. At the same time, however, significant differences, mainly in manufacturing techniques and typology, suggest the existence of diverse stone-working traditions that, in geographical terms, appear to roughly reflect a north-south divide. More specifically, by some indications, the Neolithic communities of Northern Greece seem more Balkan-oriented in terms of their rather complex edge tool technologies when compared to the communities from the southern mainland and the islands, which – in some cases – give the impression of being technically more »straightforward«.

Keywords edge tools, Neolithic, stone tool technology, Greece, technical traditions

Introduction

Polished edge tools (i.e., axes, adzes, and chisels), often referred to as celts or ground edge tools, form one of the most recognisable categories of ground stone tools (alternatively, macrolithic tools). Their main diagnostic feature is a sharp polished bit at one of their two ends. They were used with direct or indirect percussion or pressure, usually as composite tools attached to or inserted into a wooden, bone, or antler haft (Moundrea-Agrafioti 1981; Moundrea-Agrafioti 1992).

Although we now know that edge tools were manufactured and used by prehistoric people in various parts of the world before the establishment of true agricultural systems (Hiscock et al. 2016; Yerkes et al. 2012), their significance as a central element of the Neolithic economy, tied to key activities at the core of the new agrarian lifeway, was recognised early on by scholars. In Greece, the first edge tools appeared alongside the first agropastoral settlements of the 7th millennium BC and continued to be used long after the advent of metals (Moundrea-Agrafioti 1996). In Northern and Western Europe, studies on edge tools advanced quickly,

DATE BC	PHASES	ABBREVIATIONS
6700/6500–5800	Early Neolithic	EN
5800–5400/5300	Middle Neolithic	MN
5400/5300–4800	Late Neolithic I	LN I
4800–4600/4500	Late Neolithic II	LN II
4600/4500–3300/3100	Final Neolithic/Chalcolithic	FN

Tab. 1 Dates and archaeological phases for the Greek Neolithic.

Tab. 1 *Datierungen und archäologische Phasen des griechischen Neolithikums.*

exploring issues beyond the material dimension of technology[1] and shedding light on the choices, actions, and identities of the social agents who produced and used them. In the Aegean world, however, although edge tools were ›more visible‹ to scholars than other ground stone tool categories, their study remained limited in scale and scope for many decades (Tsoraki 2011). Only in recent years has there been a surge in the systematic analysis of ground stone tool assemblages from individual archaeological sites, bringing the study of edge tools to the forefront alongside other long-understudied tool categories, such as grinding tools.

As a result, we now have in our hands a series of specialised studies from a number of excavated sites, mainly located in Northern Greece, that paint a picture of diverse coexisting practices and traditions regarding the raw material selection, manufacture, use, and disposal of edge tools. This paper seeks to combine the available published data pertaining to the Neolithic edge tool technologies of Greece (7th–4th millennia BC) and to provide an interregional and diachronic overview (Tab. 1–2). The main attributes of the edge tool technological traditions are mapped, and, through their comparative analysis, regional and supra-regional patterns of behaviour are investigated and highlighted.

Methods and constraints

A review of the literature highlights several limitations that should be mentioned here.

Several factors stemming from the current state of research in the Aegean contribute to a research image of uneven detail. Our knowledge of the Neolithic in Northern and Central Greece is well substantiated due to a wealth of excavations, many of which are extensive and systematic. By contrast, although a significant number of regional surveys of Southern Greece and the islands have been executed in recent decades (e.g., Georgiadis 2012; Runnels et al. 1995; Watrous et al. 2017), there are only a few Neolithic reference sites that have been excavated to some extent and for which published data is available.

Information on edge tools (and other ground stone tool categories) from various Greek Neolithic sites is inconsistent due to differing approaches by scholars. Detailed publications of Greek edge tool assemblages are rare, and regional or diachronic studies are absent. From the published material, only a few assemblages have been subject to an in-depth analysis by ground stone specialists[2]. Despite the existence of some non-specialist yet thorough publications of excavated sites, not all provide references on individual specimens, hindering data quantification. Many other publications only mention the total number of tools recovered (sometimes even this basic information is lacking) in sections labelled »small finds«, but without further details on their techno-morphological characteristics or contexts of recovery. Additionally, inconsistent terminology and a lack of specialised classification schemes[3] pose further obstacles to comparative data analysis.

To address these limitations and maximise the information extracted from the diverse set of data available, both quantitative and qualitative data were stored in the database created for the needs of this study. The data derive mostly from publications on various prehistoric sites across Greece, and only in a few cases from unpublished archaeological material. They relate to all stages of a tool's life-cycle: from raw material selection, production processes, and practices of curation to episodes of use/reuse/secondary use or recycling and their final abandonment/disposal/deposition. Aspects of typology, morphometrics, preservation, contexts of retrieval, and co-findings have also been recorded. Due to limitations in the extent of this overview, the focus has been placed exclusively on the Neolithic period. In total, data on the assemblages of 58 sites have been collected (Fig. 1). Data from surface surveys (regional or site-specific) were not included. The single exception, Vrastero, Western Macedonia, is a survey complemented by excavation. Through the collection, analysis, correlation, and interpretation of data, the objective is to uncover patterns and trends that may reveal diverse coexisting practices and traditions and, in a broad manner, shed light on social and cultural phenomena. Efforts have been made to quantify, where possible, the available information and to produce tables illustrating the results. However, as mentioned, not all publications are equally analytical. A basic consequence is that, in some cases, the absence of references to a trait cannot be interpreted by default as an indication of its absence. Therefore, some tool features, although potentially important indicators (of choices, trends, identities, etc.), could not be (fully) exploited at this point.

1 E.g., Bradley/Edmonds 1993; Edmonds 1995; Pétrequin et al. 1998; Ricq-de Bouard 1996.

2 E.g., Almasidou 2019; Bekiaris 2018; Chadou 2011; Chondrou 2018; Ninou 2022; Stroulia 2010; Stroulia 2018; Stroulia 2018a; Tsoraki 2008.

3 To date, many scholars apply the classification system structured by C. Tsountas in his pioneering work in the early 20th century, based on the edge tool assemblages from Sesklo and Dimini, two Thessalian sites in Central Greece (see Tsountas 1908). However, the abundance of new excavation data brought to light in the last decades from different regions of the country calls for the creation of new classification systems adapted to the specific characteristics of each geographical area.

NO.	SITE	PUBLICATION	DATE	EDGE TOOLS	TOTAL NUMBER OF EDGE TOOLS (n)
1	Makri	(1) Melfos et al. 2001 (2) Stroulia 2005a	MN–LN	YES	92
2	Dikili Tash	(1) Séfériadès 1992	EN–FN	YES	54 (30 MN + 24 LN/FN)
3	Sitagroi	(1) Elster 2003 (2) Elster 2003a (3) Dixon 2003 (4) Dixon 2003a	late MN/(early) LN–FN	YES	73 (based on Elster 2003, Tab. 5,2)
4	Olynthus	(1) Mylonas 1929	LN	YES	72
5	Koroneia	(1) Almasidou 2019	MN–LN	YES	64
6	Stavroupoli	(1) Alisøy 2002	MN–LN	YES	27
7	Agrosykia	(1) Chrysostomou et al. 2007	FN	YES	1 stratified and at least 5 more
8	Sosandra	(1) Georgiadou 2015	EN	YES	4
9	Nea Nikomedeia	(1) Rodden 1962 (2) Rodden 1964 (3) Rodden/Rodden 1964 (4) Rodden/Rodden 1964a (5) Sugaya 1992	EN	YES	
10	Paliambela	(1) Siamidou 2017	EN–LN	YES	
11	Makriyalos	(1) Yerousi 1999 (2) Tsoraki 2007 (3) Tsoraki 2008 (4) Tsoraki 2011 (5) Tsoraki 2011a (6) Tsoraki 2011b	LN	YES	1893
12	Kleitos	(1) Chondrou 2018 (2) Chondrou 2022	LN–FN	YES	1101
13	Toumba Kremasti Koilada	(1) Chondrou 2011 (2) Stroulia 2014 (3) Stroulia/Chondrou 2013	LN	YES	> 600
14	Megalo Nisi Galanis	(1) Stroulia 2005 (2) Fotiadis et al. 2019	EN–early FN	YES	36
15	Mavropigi–Fyllotsairi	(1) Ninou 2022	EN	YES	164
16	Koromilia	(1) Bekiaris 2018, 24–26; 210	LN	YES	around 100
17	Avgi	(1) Bekiaris et al. 2017 (2) Bekiaris 2018	MN–LN	YES	176
18	Dispilio	(1) Stratouli 2002 (2) Melfos/Stratouli 2002	MN–FN	YES	
19	Xirolimni	(Chondrou, pers.obs.)	EN	YES	
20	Servia	(1) Mould/Wardle 2000 (2) Mould et al. 2000	EN–LN	YES	66 stratified
21	Varemenoi Goulon	(1) Stroulia 2018a	EN–MN	YES	2335 (surface finds and excavation material, semifinished/finished specimens and production debris)
22	Vrastero	(1) Dimaki et al. 2023	Neolithic	YES	> 3000 (surface finds and excavation material, semifinished/finished specimens and production debris)
23	Theopetra Cave	(1) Christopoulou 2000	EN–LN	YES	28
24	Platia Magoula Zarkou	(1) Stroulia 2022	MN–LN	YES	33 (MN: 20; LN: 12; MN/LN: 1)
25	Argissa	(1) Milojčić 1962 (2) Perlès 2001 (3) Reingruber 2008	EN–LN	YES	Reingruber: 13 (EN)
26	Mandra	(Chondrou, pers. obs)	LN–FN	YES	
27	Ayia Sofia Magoula	(1) Milojčić et al. 1976	LN	YES	16 mentioned in the catalogue
28	Achilleion	(1) Winn/Shimabuku 1989	EN–MN	YES	58 (Phase I: 1; Phase II: 7; Phase III: 28; Phase IV: 22)

TO BE CONTINUED

NO.	SITE	PUBLICATION	DATE	EDGE TOOLS	TOTAL NUMBER OF EDGE TOOLS (n)
29	Visviki Magoula	(1) Bergner 2015	EN–FN	YES	109
30	Sesklo	(1) Tsountas 1908 (2) Moundrea-Agrafioti 1981 (3) Kotsakis 1981 (3) Christopoulou 1992 (3) Papathanassopoulos 1996	EN–MN	YES	112 (Christopoulou 1992)
31	Dimini	(1) Tsountas 1908 (2) Moundrea-Agrafioti 1981	LN	YES	
32	Pefkakia Magoula	(1) Weisshaar 1989	LN/FN	YES	13
33	Ayios Petros	(1) Moundrea-Agrafioti 1981 (2) Efstratiou 1985	MN	YES	22
34	Cyclops Cave	(1) Sampson/Orphanidis 2008	EN–LN	NO	
35	Ayios Vlasis	(Chondrou, pers. obs.)	EN	YES	
36	Elateia	(1) Weinberg 1962	EN–MN	YES	3 (1 EN, 1 MN)
37	Toumba Balomenou	(1) Tzavella-Evjen 2012 (2) Adam 2012	EN–LN	YES	78
38	Sarakenos Cave	(1) Davri 2023	EN–LN	YES	91 (EN: 2; MN: 10; LN: 78; one with no dating)
39	Tharrounia/ Skoteini Cave	(1) Sugaya 1993	LN–FN	YES	21 (14 from the cave, 7 from the settlement, but none from the cemetery)
40	Drakaina Cave	(1) Melfos et al. 2020 (2) Stratouli/Metaxas 2017 (3) Stratouli/Metaxas 2018 (4) Stratouli et al. 2022	LN–FN	YES	6
41	Limnes Cave	(1) Sampson 1997	LN	NO	
42	Tsoungiza	(1) Dabney et al. 2020	EN–MN / FN	YES	6
43	Ayioryitika	(1) Petrakis 2002	EN/MN–FN	YES	57
44	Lerna	(1) Banks 2015	EN–MN	YES	45
45	Anemodouri (hoard findspot)	(1) Tsountas 1901	Neolithic	YES	4
46	Franchthi Cave	(1) Stroulia 2003 (2) Stroulia 2010	EN–FN	YES	88 (62 from cave, 26 from Paralia)
47	Alepotrypa Cave	(1) Stroulia 2018	EN/LN–FN	YES	31 (EN phase: 5?/LN phase: 6/FN: 8?)
48	Kitsos Cave	(1) Perlès 1981	LN–FN	YES	8 (6 from inside the cave, 2 from outside)
49	Ayia Triada Cave	(1) Mavridis/Tankosić 2009	LN–FN	NO	
50	Kephala	(1) Coleman 1977	LN	YES	6
51	Ftelia	(1) Sampson 2002	LN	YES	4
52	Saliagos	(1) Evans/Renfrew 1968 (2) Oosterom 1968 (3) Boleti 2009	LN	YES	36
53	Yali	(1) Sampson 1988	FN	YES	4
54	Kastro (Alimnia islet)	(1) Sampson 1987	FN	NO	
55	Ayios Yeoryios Cave, Kalithies (Rhodes)	(1) Sampson 1987	LN–FN	YES	1
56	Aposelemis cemetery	(1) Agelarakis/Kanta 2020	Neolithic	YES	
57	Katsambas	(1) Galanidou/Manteli 2008	EN	YES	12
58	Knossos	(1) Evans 1964 (2) Moundrea-Agrafioti 1992	EN–LN	YES	65

Tab. 2 Sites included in the analysis, relevant publications, Neolithic dating of the sites, and number of recovered edge tools.

Tab. 2 *In der Analyse ausgewertete Fundorte, relevante Publikationen, ihre neolithische Datierung, Anzahl der entdeckten Schneidwerkzeuge.*

Fig. 1 Map of Greece with marked locations of the Neolithic sites discussed in the paper: 1 Makri; 2 Dikili Tash; 3 Sitagroi; 4 Olynthus; 5 Koroneia; 6 Stavroupoli; 7 Agrosykia; 8 Sosandra; 9 Nea Nikomedeia; 10 Paliambela; 11 Makriyalos; 12 Kleitos; 13 Toumba Kremasti Koilada; 14 Megalo Nisi Galanis; 15 Mavropigi-Fyllotsairi; 16 Koromilia; 17 Avgi; 18 Dispilio; 19 Xirolimni; 20 Servia; 21 Varemenoi Goulon; 22 Vrastero; 23 Theopetra Cave; 24 Platia Magoula Zarkou; 25 Argissa; 26 Mandra; 27 Ayia Sofia Magoula; 28 Achilleion; 29 Visviki Magoula; 30 Sesklo; 31 Dimini; 32 Pefkakia Magoula; 33 Ayios Petros; 34 Cyclops Cave; 35 Ayios Vlasis; 36 Elateia; 37 Toumba Balomenou; 38 Sarakenos Cave; 39 Tharrounia/Skoteini Cave; 40 Drakaina Cave; 41 Limnes Cave; 42 Tsoungiza; 43 Ayioryitika; 44 Lerna; 45 Anemodouri; 46 Franchthi Cave; 47 Alepotrypa Cave; 48 Kitsos Cave; 49 Ayia Triada Cave; 50 Kephala; 51 Ftelia; 52 Saliagos; 53 Yali; 54 Kastro (Alimnia islet); 55 Ayios Yeoryios Cave; 56 Aposelemis cemetery; 57 Katsambas; 58 Knossos.

Abb. 1 *Karte Griechenlands mit den neolithischen Fundstellen aus dem Beitrag: 1 Makri; 2 Dikili Tash; 3 Sitagroi; 4 Olynthos; 5 Koroneia; 6 Stavroupoli; 7 Agrosykia; 8 Sosandra; 9 Nea Nikomedeia; 10 Paliambela; 11 Makrigialos; 12 Kleitos; 13 Toumba Kremasti Koilada; 14 Megalo Nisi Galanis; 15 Mavropigi-Fyllotsairi; 16 Koromilia; 17 Avgi; 18 Dispilio; 19 Xirolimni; 20 Servia; 21 Varemenoi Goulon; 22 Vrastero; 23 Theopetra-Höhle; 24 Platia Magula Zarkou; 25 Argissa; 26 Mandra; 27 Agia Sofia Magula; 28 Achilleion; 29 Visviki-Magula; 30 Sesklo; 31 Dimini; 32 Pefkakia-Magula; 33 Agios Petros; 34 Zyklopenhöhle; 35 Agios Vlasis; 36 Elateia; 37 Toumba Balomenou; 38 Sarakenos-Höhle; 39 Tharrounia/Skoteini-Höhle; 40 Drakaina-Höhle; 41 Limnes-Höhle; 42 Tsoungiza; 43 Agiorgitika; 44 Lerna; 45 Anemodouri; 46 Höhle von Franchthi; 47 Alepotrypa-Höhle; 48 Kitsos-Höhle; 49 Höhle von Agia Triada; 50 Kephala; 51 Ftelia; 52 Saliagos; 53 Yali; 54 Kastro (Insel Alimnia); 55 Höhle von Agios Georgios; 56 Nekropole von Aposelemis; 57 Katsambas; 58 Knossos.*

Neolithic edge tool technologies in Greece – distribution and morphology

Edge tools are neither represented to the same degree in all Greek Neolithic ground stone assemblages, nor are they ubiquitous (cf. Tab. 2). This imbalance could be attributed to the different extent of the excavations: Many assemblages have resulted from limited-scale excavations, whereas far fewer derive from extensive, systematic ones. For example, the sites of Makriyalos and Kleitos, situated in Central and Western Macedonia respectively (North-Western Greece), constitute rare cases of extensive excavations that yielded

NO.	SITE	DATING	TYPE OF SITE	EDGE TOOLS	TOTAL NUMBER OF EDGE TOOLS (n)
23	Theopetra Cave	EN–LN	CAVE	YES	28
33	Ayios Petros	MN	ISLAND	YES	22
34	Cyclops Cave	EN–LN	CAVE/ISLAND	**NO**	
38	Sarakenos Cave	EN–LN	CAVE	YES	91
39	Tharrounia/Skoteini Cave	LN–FN	CAVE/ISLAND	YES	21 (14 from the cave, 7 from the settlement)
40	Drakaina Cave	LN–FN	CAVE/ISLAND	YES	6
41	Limnes Cave	LN	CAVE	**NO**	
46	Franchthi Cave	EN–FN	CAVE	YES	88 (62 from the cave, 26 from the Paralia)
47	Alepotrypa Cave	EN/LN–FN	CAVE	YES	31 (EN phase: 5?/LN phase: 6/FN: 8?)
48	Kitsos Cave	LN–FN	CAVE	YES	8 (6 from inside the cave, 2 from outside)
49	Ayia Triada Cave	LN–FN	CAVE/ISLAND	**NO**	
50	Kephala	LN	ISLAND	YES	6
51	Ftelia	LN	ISLAND	YES	4
52	Saliagos	LN	ISLAND	YES	36
53	Yali	FN	ISLAND	YES	4
54	Kastro (Alimnia islet)	FN	ISLAND	**NO**	
55	Ayios Yeoryios Cave, Kalithies (Rhodes)	LN–FN	CAVE/ISLAND	YES	1
56	Aposelemis cemetery	Neolithic	ISLAND	YES	?
57	Katsambas	EN	ISLAND	YES	12
58	Knossos	EN–LN	ISLAND	YES	65

Tab. 3 Cave and island sites and the number of edge tools retrieved per site.

Tab. 3 *Fundorte in Höhlen und auf Inseln sowie die Anzahl der bekannten Schneidwerkzeuge je Fundort.*

the two largest edge tool assemblages originating from excavated Greek Neolithic sites[4]. However, an examination of the origin of the assemblages that contain fewer than 10 edge tools or none at all shows that all but four originate from cave and cave/island sites (the caves of Ayia Triada in Euboea, Ayios Yeoryios in Rhodes island, Dodecanese, Cyclops in Youra island, North Aegean, Drakaina in Kefalonia island, Western Greece, Kitsos in Attica, and Limnes in the Peloponnese) or island sites (Ftelia in Mykonos island, Cyclades, Yali in the Dodecanese, Kastro in Alimnia island, Dodecanese, and Kephala in Kea island, Cyclades; Tab. 3). The four exceptions come from small-scale excavations[5] (Agrosykia in Central Macedonia, Elateia in Central Greece, Sosandra in Central Macedonia, and Tsoungiza in the Peloponnese), suggesting that the limited number of relevant finds may be due to the lesser extent of the excavation.

If the overall pattern is not the result of research bias, then the varying presence of the tools in question could be linked to the diversified economy of the communities inhabiting and utilising these insular and cavernous landscapes and to the differentiated needs imposed by their particular environment (see also Stroulia 2003, 129), or to a special function these sites might have. Indeed, for some cave sites, the idea of their ritual use (whether exclusive or not) has been proposed – e.g., for the caves of Alepotrypa in the Peloponnese (Stroulia 2018) and Drakaina (Stratouli/Metaxas 2017; Stratouli/Metaxas 2018). Perhaps, therefore, the activities systematically carried out at these sites may not have necessitated the use of edge tools. Alternatively, it is possible that these tools were employed in activities performed outside the cave premises, leading to a different pattern of deposition or disposal compared to other tool types. Different regional trajectories may also contribute to this phenomenon. For example, in the Dodecanese islands, South Aegean, the introduction and use of metals, occurring earlier than in mainland Greece, may account for the limited use of stone tools and the scarcity of edge tools, at least as far as the later phases of the Neolithic are concerned (Sampson 1987, 133).

There are of course caves and island sites that do not conform to this pattern, such as the Franchthi Cave, Peloponnese, that yielded a total of 88 finds from its Neolithic strata (Stroulia 2010), or Saliagos, South Aegean, with 36 finds (Evans/Renfrew 1968). Furthermore, differences in edge tool concentration are evident within the same island or between neighbouring ones, suggesting that varying traditions may be at play among closely situated communities (see, for example, the case of the Dodecanese islands,

4 See Tsoraki 2008; Tsoraki 2011; Chondrou 2018; Chondrou 2022. Two other assemblages from the sites of Varemenoi Goulon and Vrastero, again from North-western Greece, comprise a large number of surface finds (Stroulia 2018a; Dimaki et al. 2023).

5 A fifth case, Anemodouri, is not an excavation but the findspot of a stray find.

Fig. 2 The largest currently known edge tool from Neolithic Greece with its three associated finds (findspot: Anemodouri, Peloponnese).

Abb. 2 *Das größte bisher bekannte Schneidwerkzeug aus dem neolithischen Griechenland mit den drei vergesellschafteten Funden (Fundstelle: Anemodouri, Peloponnes).*

Georgiadis 2017). The most striking exception, however, is the case of the Sarakenos Cave, Central Greece, which yielded a stunning total of 91 edge tools, mostly from Late Neolithic (LN) deposits (Davri 2023). It is evident, therefore, that a single explanation cannot account for the observed diversity.

It has been suggested that edge tools became gradually established in the Greek Neolithic toolkit, with minimal presence in the earliest Neolithic phases (EN I) and small dimensions that could hardly be compatible with a tree-cutting function (Perlès 2001; Theocharis 1967), but growing larger and more abundant later on. Indeed, the majority of data seems to fit into the proposed model, and there are several cases, such as Achilleion, Sesklo, both in Thessaly, and Franchthi, where the number of edge tools is limited in their Early Neolithic (EN) phases but increases over time. A similar observation has been made regarding the island of Crete in South Aegean (Moundrea-Agrafioti 1992, 175). However, this pattern could be influenced by preservation factors and the general scarcity of data on the earliest EN phases (Moundrea-Agrafioti 1981, 241–244). Alternatively, it could mean that land-clearing with the use of stone edge tools was not as important an activity at that time as previously assumed (Moundrea-Agrafioti 1981, 244).

From a metrical point of view, Greek edge tool assemblages tend to be relatively small-sized (Tab. 4). There are many factors to account for the limited size of an edge tool, related to both manufacture and use. For example, the inherent form and size of raw materials available in each region constrain the size of the resulting tools. Moreover, the wear incurred during use necessitates regular resharpening of the tool to maintain the functionality of its cutting edge, which gradually reduces tool dimensions. Extensive breakages and subsequent repair activities can result in

NO.	SITE	DATE	DIMENSION RANGE (Length-Width-Thickness) *based on intact specimens	AVERAGE DIMENSIONS (Length-Width-Thickness) *based on intact specimens
2	Dikili Tash	EN–FN	2.70–11.20 x 0.90–6.30 x 0.70–3.10 cm	
3	Sitagroi	late MN/ (early) LN–FN	3.20–14.90 x 1.60–5.00 x 0.80–2.90 cm	6.42 x 3.55 x 1.60 cm
4	Olynthus	LN	3.50–13.00 x 1.10–4.60 x 1.00–2.50 cm	
5	Koroneia	MN–LN	2.60–10.80 cm length x 1.20–5.80 cm width	
6	Stavroupoli	MN–LN		7.30 x 4.13 x 1.74 cm
8	Sosandra	EN	5.00–13.40 x 1.10–5.30 x 1.00–4.40 cm	7.85 x 3.35 x 2.00 cm
11	Makriyalos	LN	1.80–14.40 x 0.60–6.90 x 0.30–5.20 cm	4.90 x 3.50 x 2.10 cm
12	Kleitos	LN–FN	2.10–19.60 x 1.10–7.30 x 0.30–4.10 cm	5.60 x 3.10 x 1.40 cm
13	Toumba Kremasti Koilada	LN	3.00–14.00 cm length (but there are fragments of even bigger tools, e.g., a refitted tool with a length of 17.00 cm)	7.00 x 3.70 x 2.00 cm
14	Megalo Nisi Galanis	EN – early FN	3.00–10.00 cm length	
15	Mavropigi-Fyllotsairi	EN	3.00–26.00 x 1.00–7.00 x 1.00–7.00 cm	
17	Avgi	MN–LN	2.50–12.40 x 1.10–6.90 x 0.40–4.30 cm	7.10 x 3.50 x 2.00 cm
20	Servia	EN–LN	2.60–20.00 x 0.90–7.60 x 0.50–5.40 cm	8.26 x 4.00 x 2.01 cm
21	Varemenoi Goulon	EN–MN	2.70–17.70 x 1.50–6.30 x 0.40–5.30 cm (but most fragments originate from large tools 13.00–15.00 cm in length)	8.30 x 3.90 x 2.50 cm
23	Theopetra Cave	EN–LN	3.40–8.40 x 0.80–5.50 x 0.70–3.10 cm	5.40 x 3.12 x 1.54 cm
24	Platia Magoula Zarkou	MN–LN	3.00–13.60 x 1.20–4.90 x 0.80–3.50 cm	6.50 x 3.60 x 1.90 cm
29	Visviki Magoula	EN–FN	AXES: 3.10–8.50 length x 1.10–5.10 cm width (the majority of tools measure 4.00–6.00 cm in length) / ADZES: 3.30–14.60 length x 2.20–4.70 cm width (the majority of tools measure 4.00–6.00 cm in length)	
30	Sesklo	EN–MN	2.50–10.50 cm length	
37	Toumba Balomenou	EN–LN		Group I: 9.40 x 4.70 x 3.50 cm/ Group II: 4.00 x 2.90 x 1.30 cm
38	Sarakenos Cave	EN–LN	1.90–13.50 x 0.80–5.70 x 0.40–4.50 cm	5.46 x 3.27 x 1.77 cm
39	Tharrounia/ Skoteini Cave	LN–FN	2.30–6.30 cm length + one specimen 14.90 cm	
40	Drakaina Cave	LN–FN	2.00–7.00 cm length	
44	Lerna	EN–MN	4.80–9.33 x 2.14–5.62 x 1.60–3.70 cm	7.00 x 4.19 x 2.86 cm
45	Anemodouri (hoard findspot)	Neolithic	5.90–27.80 cm length	
46	Franchthi Cave	EN–FN	2.00–9.60 x 0.80–4.90 x 0.40–3.70 cm	4.54 x 3.01 x 1.67 cm
47	Alepotrypa Cave	EN/LN–FN	2.70–8.70 x 1.40–5.20 x 0.80–3.40 cm	4.80 x 3.20 x 1.70 cm
48	Kitsos Cave	LN–FN	2.80–6.60 x 1.30–4.80 x 0.90–1.90 cm	3.75 x 2.65 x 1.32 cm
50	Kephala	LN	3.00–8.20 x 1.70–4.20 x 1.00–2.40 cm	5.53 x 2.57 x 1.45 cm
52	Saliagos	LN	< 6.00 cm	
57	Katsambas	EN	small ones: 4.50–6.00 cm length – larger ones: 8.00–8.40 cm length	
58	Knossos	EN–LN	1.40–10.70 x 2.50–7.00 x 0.80–3.70 cm	5.45 length x 4.25 cm width

Tab. 4 Range of edge tool dimensions and average dimensions per site, where available or possible to calculate.

Tab. 4 *Kleinste und größte sowie Durchschnittmaße der Schneidwerkzeuge je Fundort, sofern diese vorliegen oder berechnet werden können.*

Fig. 3 A quartz crystal shaped by abrasion to resemble a miniature edge tool. It was probably used as an amulet (LN Kleitos, Western Macedonia).

Abb. 3 *Quarzkristall, der durch Abschleifen einem Miniaturschneidwerkzeug gleicht. Er wurde vermutlich als Amulett verwendet (Spätneolithikum, Kleitos, Westmakedonien).*

even more rapid dimensional changes. In addition, edge tools are often secondarily used (e.g., as pounders or abrasive tools), resulting in alterations to their original form. Evidence from the Makriyalos assemblage supports the idea of size reduction through use: Larger tools bear signs of heavier use and abundant evidence of resharpening compared to smaller ones (Tsoraki 2008, 88–89). In the case of the Franchthi and Alepotrypa assemblages, on the other hand, where no intact specimen exceeds 10 cm in length, the exact opposite has been observed: Larger tools do not display evidence of intense resharpening, unlike smaller ones. In these cases, the predominance of small tools has been interpreted as a deliberate function-related manufacturing choice, with potential (additional) symbolic, non-utilitarian dimensions, at least in some instances (Stroulia 2003, 71–79; Stroulia 2018, 214).

The small size of Greek Neolithic edge tools – certainly the result of a combination of factors – contrasts sharply with their generally much larger Western European counterparts (Tsoraki 2008, 88). Interestingly, however, a difference in tool size emerges when comparing sites from Northern and Southern Greece, with edge tools from the north being typically larger than those from the south. This discrepancy may be linked to the type and function of the sites, since most of the Neolithic sites investigated in the south are caves (Stroulia 2018, 213–214).

There are only a few exceptions of oversized tools in archaeological assemblages from Neolithic Greece. The four largest specimens identified so far include one tool from Anemodouri, in the Peloponnese, measuring about 28 cm in length and weighing over 1.5 kg (Fig. 2; Tsountas 1901), two tools from Nea Nikomedeia, Central Macedonia, measuring 27.5 cm and 26 cm in length (Sugaya 1992), and one tool from Mavropigi-Fyllotsairi, Western Macedonia, slightly exceeding 26 cm in length (Ninou 2022). They all constitute extreme rarities and are rather unlikely to have had a utilitarian function (Sugaya 1992) as they originate from special contexts of possible ritual and symbolic character. The intriguing find from Anemodouri was part of a hoard of four axes recovered from a ceramic vessel that also contained charcoal, which was surrounded by scattered potsherds and fragments of obsidian blades (Tsountas 1901). The Nea Nikomedeia axes were found alongside clay female figurines in a building identified as a ›shrine‹ by the excavator (Rodden 1964; Rodden/Rodden 1964; Rodden/Rodden 1964a), whereas the tool from Mavropigi-Fyllotsairi was found in association with a burial (Ninou 2022). The special attributes of these finds, along with their context of retrieval and other oversized finds – although of no such metrical extremes – from other sites, combine with other features to suggest a possible symbolic dimension of these artefacts (Sampson/Sugaya 1989). These features may include the possible presence of colouring substances on the surfaces of some of them (Sugaya 1992, 72), the existence of extremely finely made ›greenstone miniature axes‹ and other small well-made edge tools of various materials (Fig. 3) that possibly functioned as amulets (see Gimbutas 1989, 333, for the case of Achilleion; Stroulia 2010, 76–77 for the Franchthi

NO.	SITE	DATE	MAIN RAW MATERIAL	SIGNS OF QUARRING	SIGNS OF LOCAL MANU-FACTUTING	FLAKING	SAWING	DRILLING
1	Makri	MN–LN	(various in unknown percentages: greenschist, serpentine, metagab-bro)			YES		
2	Dikili Tash	EN–FN	(various in unknown percentages: jadeite?, limestone, silex etc.)				YES (based on Séfériadès 1992, Tab. 178b)	
3	Sitagroi	late MN/(early) LN–FN	metadolerite, metagabbro	YES			YES	YES (n = 2)
4	Olynthus	LN	(various in unknown percentages: black ironstone, limestone, soaps-tone)				YES	
5	Koroneia	MN–LN	serpentinite		5 unfinished specimens	YES	YES	YES (n = 1)
6	Stavroupoli	MN–LN	serpentinite			(possible)	YES (n = 1)	
7	Agrosykia	FN						
8	Sosandra	EN	serpentinite, gabbro					
9	Nea Nikomedeia	EN	marble, serpentine	YES ? – with sawing			YES	
10	Paliambela	EN–LN						
11	Makriyalos	LN	serpentinite	YES – limited indications of sawing application		YES (n=2, according to Tsoraki 2008, Tab. 4,26–30)	YES	
12	Kleitos	LN–FN	serpentinite		15 unfinished specimens and production debris	YES	YES	YES (n = 5)
13	Toumba Kremasti Koilada	LN	serpentinite, gabbro		YES	YES	YES – rare	YES (n = 3)
14	Megalo Nisi Galanis	EN–early FN	serpentinite, gabbro		YES	YES	YES	
15	Mavropigi-Fyllotsairi	EN	serpentinite			YES	YES	
16	Koromilia	LN	gneiss, granite, amphibolite			YES	YES	
17	Avgi	MN–LN	serpentinite	YES	9 unfinished specimens and possible production debris?	YES	YES	
18	Dispilio	MN–FN	serpentinite	YES	YES (workshop)		YES	
19	Xirolimni	EN				YES – rare?	YES	
20	Servia	EN–LN	serpentinite, basalt		a few flakes (unstratified) and unfinished specimens (phase 2, 3, 7)	YES	YES	
21	Varemenoi Goulon	EN–MN	gabbro		YES (workshop)	YES	YES – rare	YES (n = 2)

NO.	SITE	DATE	MAIN RAW MATERIAL	SIGNS OF QUARRING	SIGNS OF LOCAL MANU-FACTUTING	FLAKING	SAWING	DRILLING
22	Vrastero	Neolithic	ophioliths		YES (workshop)	YES		
23	Theopetra Cave	EN–LN	ophioliths					
24	Platia Magoula Zarkou	MN–LN	gabbro, serpentinite			YES (n = 1)	YES (n = 1)	
25	Argissa	EN–LN	greenstone (Reingruber 2008)					
26	Mandra	LN–FN				YES – rare	YES	
27	Ayia Sofia Magoula	LN						
28	Achilleion	EN–MN	serpentine or jadeite		at least 1 unfinished specimen			
29	Visviki Magoula	EN–FN	serpentinite, amphibolite					YES (n = 2)
30	Sesklo	EN–MN			YES	YES	YES	
31	Dimini	LN				YES		
32	Pefkakia Magoula	LN/FN						
33	Ayios Petros	MN	red volcanic stone				YES	
34	Cyclops Cave	EN–LN						
35	Ayios Vlasis	EN			YES *possible workshop	YES	YES – rare	
36	Elateia	EN–MN	basalt, greenstone					
37	Toumba Balomenou	EN–LN	(various in unknown percentages: basalt, serpentinite, steatite, tuff)					
38	Sarakenos Cave	EN–LN	greenstones (meta-ophiolite group)					
39	Tharrounia/Skoteini Cave	LN–FN						
40	Drakaina Cave	LN–FN	gabbro					
41	Limnes Cave	LN						
42	Tsoungiza	EN-MN/FN	granite, serpentinite					
43	Ayioryitika	EN/MN–FN	greenstone					
44	Lerna	EN–MN	serpentinite					
45	Anemodouri (hoard findspot)	Neolithic	jadeite, diabase, greenstone					
46	Franchthi Cave	EN–FN	serpentinite		YES	YES (n = 1)		
47	Alepotrypa Cave	EN/LN–FN	metavolcanic material		only 1 possible unfinished specimen			
48	Kitsos Cave	LN–FN	serpentinite, jadeite					
49	Ayia Triada Cave	LN–FN						

NO.	SITE	DATE	MAIN RAW MATERIAL	SIGNS OF QUARRING	SIGNS OF LOCAL MANUFACTUTING	FLAKING	SAWING	DRILLING
50	Kephala	LN	(2 emery)			(possibly, judging by the drawing and photos of two artefacts, Nr. 1 and 38)		
51	Ftelia	LN	greenstone					
52	Saliagos	LN	emery			YES		
53	Yali	FN	sandstone					
54	Kastro (Alimnia islet)	FN						
55	Ayios Yeoryios Cave, Kalithies (Rhodes)	LN–FN	flint					
56	Aposelemis cemetery	Neolithic						
57	Katsambas	EN	metamorphic stones					
58	Knossos	EN–LN	serpentinite		one or two possible unfinished specimens (Evans 1964, Fig. 51,11; Pl. 54.4,1)	YES (n = 2)	YES	

Fig. 4 A semi-finished example of Tsountas's type A edge tool with almost circular section (Neolithic, Vrastero, Western Macedonia).

Abb. 4 *Halbfertiges Schneidwerkzeug von Christos Tsountas' Typ A mit fast rundem Querschnitt (Neolithikum, Vrastero, Westmakedonien).*

Cave), and certain stylised figurines that morphologically resemble edge tools[6]. An example of the last category of finds is the 24.5 cm long axe-shaped object from Sesklo with traces of ochre, initially interpreted as a stylised painted figurine (Tsountas 1908, 288–289; 306 Fig. 230b).

In terms of morphology, edge tools exhibit a remarkable diversity, which sometimes appears to be a deliberate manufacturing choice and at other times seems more closely related to the initial morphology of the raw material used. However, one specific morphological type is worthy of special mention, as it is identified within the typological scheme of Tsountas (1908) as one of the characteristic tool types of the Thessalian world: the spindle-shaped robust axe with a circular or oval section (Type A, Fig. 4). The interesting thing about this type is that it appears to have a rather specific distribution: It is present on the Thessalian plain – e.g., at Sesklo and Dimini (Moundrea-Agrafioti 1985; Tsountas 1901) – and in the southern part of Central Greece – e.g., at Toumba Balomenou (Tzavella-Evjen 2012)

Tab. 5 Main raw materials used for edge tool production and different traces of manufacture per site.

Tab. 5 *Hauptrohstoffe für die Herstellung von Schneidwerkzeugen und die verschiedenen Herstellungsspuren je Standort.*

Fig. 5 Semi-finished edge tools representing various stages of their production sequence (Neolithic, Vrastero, Western Macedonia).

Abb. 5 *Halbfertige Schneidwerkzeuge in verschiedenen Herstellungsstadien (Neolithikum, Vrastero, Westmakedonien).*

and Ayios Vlasis (Chondrou, pers. obs.) – whereas, to the north of the Thessalian plain, it turns up at some sites – e.g., at Servia (Mould et al. 2000, 139–146), Varemenoi Goulon (Stroulia 2018a), and Vrastero (Chondrou, pers. obs.) all situated in Western Macedonia – but not at others in the same region – e.g., at Kleitos and Toumba Kremasti Koilada (Chondrou 2011; Chondrou 2018).

Neolithic edge tool technologies in Greece – raw materials and manufacture

Regarding the locales of edge tool production, the available evidence varies. In a series of sites, only a few semi-finished specimens are preserved (Tab. 5). If the scant representation of manufacturing remains is not due to the limited extent of the excavation, we may be dealing with a hybrid model of tool acquisition, where some tools arrive at the settlement as ready-made artefacts but others as raw materials to be shaped *in situ*. Alternatively, (some) tools may have arrived in a semi-finished form to be completed on site. In any case, one would expect redesigning practices – just as with maintenance activities, i.e., resharpening – to have been executed on site (as well). There are, however, the cases of Dispilio (Stratouli 2002), Varemenoi Goulon (Stroulia 2018a), Vrastero (Dimaki et al. 2023), all in Western Macedonia, and Ayios Vlasis (Chondrou pers. obs.) in Central Greece, where the bulk of the available evidence suggests mass tool production in organised workshops (Fig. 5). Thus, while the simplest forms of edge tools could have been made by any Neolithic individual, their greatest requirement being patience rather than any particularly complex know-how, the existence of workshops implies an early form of technical specialisation and division of labour and confirms that the production of edge tools in Neolithic Greece was – to some extent – a specialised craft. At least three of these workshops are associated with settlements, suggesting the existence of communities oriented to the production and distribution of such implements.

Regarding the manufacture of edge tools, the available evidence testifies to a significant degree of variability in all stages of the production sequence, from raw material acquisition to the formation of the final product. The rocks used as raw materials belong to all three major geological groups: metamorphic, igneous, and sedimentary. Among the most preferable materials are serpentinite and gabbro. However, since many publications refer to ›greenish rocks‹ without further explanation or supplementary data from petrographic, mineralogical, or geochemical analyses, there is no feasible way to determine the actual numbers. Nevertheless, what can be said is that a distinct and widespread preference for serpentinite is evident in numerous Greek settlements throughout the Neolithic period (see also Moundrea-Agrafioti 1996, 104; Perlès 2001, 232). Since the natural properties of the rock would have played a vital role in raw material selection (Delgado-Raack et al. 2020), scholars have associated this particular choice of serpentinite with the rock's softness and, therefore, easiness to shape, although it is exactly this soft-

6 Sugaya (1992, 75) has raised questions regarding the existence of a ›stone-axe belief‹ associated with the deification of edge tools within certain ritual contexts.

Fig. 6 Two examples of the identifiable group of tools made of a particular variety of serpentinite that probably came to Kleitos from Dispilio, both Western Macedonia.

Abb. 6 *Zwei Beispiele für die identifizierbare Gruppe von Werkzeugen aus bestimmten Serpentinitarten, welche wahrscheinlich von Dispilio nach Kleitos, beide Westmakedonien, gelangten.*

ness that raises questions about the functions of the tools produced (see Stroulia 2003, 66; Tsoraki 2011b, 296). In the case of Makriyalos, the use of durable igneous rocks such as basalt for some tools was interpreted as a function-related choice, although it would also entail more time-consuming production processes (Tsoraki 2008, 109). At the same time, however, a relation between specific rock categories and tool types (coarse igneous rocks for axes, finer ones for adzes, serpentinite for chisels) was found to not fully comply with functional criteria (Tsoraki 2011b, 289; 295).

Colour (and colour patterning) is another natural property of stone that, as demonstrated by some site-specific specialised studies, would not have been overlooked by prehistoric people (Bekiaris et al. 2017; Chondrou 2018; Tsoraki 2011b). The techniques of grinding and especially polishing that were applied in the formation of edge tools enhanced the colour properties of rocks, making them distinctive and recognisable. In the case of Kleitos, the preference for certain materials over others in edge tool technology has been linked to the visual appearance of the tools, to their recognisability, and to the potential projection of particular identities in a very densely populated area (Chondrou 2018; Chondrou 2022).

The availability of the raw material, its accessibility, and one's own proximity to its source(s), as well as the origin of the raw material (with any associated connotations), would have certainly influenced the selection of rocks. In most cases, the raw materials used for edge tool production were locally or regionally available, but cases of exploitation of more distant sources are also known. For example, in the earliest phase of Sitagroi, Eastern Macedonia, only local stones were used, later supplemented by imported materials from outside the Drama region (Elster 2003, 185). In Tsoungiza, Southern Greece, all the rocks used for edge tool production were brought from further away (Dabney et al. 2020). In Franchthi, although the majority of tools were made of locally/regionally available raw materials, there are singular occurrences of non-local rock types such as andesite and fired steatite (Stroulia 2010, 66; 126). At Knossos, Crete, in South Aegean, the raw materials came from distant areas of the island (Strasser 2004; Strasser 2008; Strasser/Fassoulas 2004), whereas, at Ayios Petros in the Sporades, North Aegean, and at Saliagos in the Cyclades, South Aegean, materials came from outside the islets, i.e., from the nearby island of Psathouras (Moundrea-Agrafioti 1981, 180) and from the emery deposits of Naxos Island

(Oosterom 1968, 99), respectively. In the Drakaina Cave on the island of Kephalonia, the gabbro used for edge tools must have been of an even more distant origin since it does not occur on any Ionian island and most probably came from the area of Pindos on mainland Greece (Melfos et al. 2020). The limited number of axes made of basalt found in certain Dodecanese islands (e.g., Karpathos, Symi) suggests the importation of this volcanic material (whether as a raw material or as finished objects remains unknown), complementing the exploitation of the local stone sources (Georgiadis 2017). Finally, with regard to the relatively limited number of jadeite edge tools found in Greece and elsewhere in Southeast Europe, field investigations and analyses have partially confirmed an earlier hypothesis: the raw material of many – though not all – sampled Greek finds was traced to the island of Syros (Sørensen et al. 2017). However, the quantity and quality of these finds suggest that the production on Syros, although it predates the exploitation of Alpine sources (Sørensen et al. 2017), was limited, as was the circulation of these products. This supports the idea that the majority of Southeast European jadeite finds likely had an Alpine origin (Pétrequin et al. 2017).

The aforementioned examples illustrate the extensive circulation of raw materials and/or finished artefacts, often spanning several dozen kilometres. However, these movements and exchanges did not always have the same form and mechanisms of execution, nor did they serve the same needs or carry equivalent meanings and values. This is exemplified by the case of Kleitos, located in the alluvial Kitrini Limni basin in North-western Greece, where the absence of suitable raw materials forced the local communities to turn to raw material sources outside their immediate vicinity from locations more than 20 km away, at least as far as good-quality material is concerned (Chondrou 2018). Analysis of the Kleitos edge tool assemblage revealed a distinct and identifiable group of edge tools of high craftsmanship and good-quality serpentinite possibly originating from Dispilio, approximately 50 km away. If this is the case, it would mean the existence of a regional network of edge tool circulation (Fig. 6; Chondrou 2018; Chondrou 2022, 251–252), which, according to the evidence, supplied at least one more settlement in Western Macedonia, Avgi (Bekiaris et al. 2017; Stratouli 2019). Additionally, four tools in the same assemblage were made of ophitasvestite (green Thessalian stone), a rare and hard serpentinite breccia known for its impressive optical traits and found approximately 100 km away, in the area of Larissa, Central Greece (Melfos 2008 and pers. comm.). The exchange systems for these two cases – the tools possibly originating from Dispilio and the tools made of ophitasvestite – may differ significantly. Finds with a very limited presence in overall assemblages, such as the ophitasvestitic rarities found in Kleitos, could represent small-scale exchanges (between individuals or groups), gifts, random discoveries, or travel mementos (for a similar hypothesis on a different assemblage, see Stroulia 2003, 126–127).

The available data suggest that the most common strategy of raw material acquisition for edge tool production was the exploitation of secondary deposits, such as stream and river beds, achieved through the collection of pebbles and cobbles. In a few cases, the collection of naturally detached or fragmented material from primary sources has also been proposed, whereas the exploitation of primary sources through quarrying is extremely rare (cf. Tab. 5; note: in none of the cases where quarrying is mentioned has the specific site of Neolithic material extraction been identified).

Edge tools were the result of specific production sequences that usually required significant work investment, involving multiple manufacturing techniques, specific technical means (e.g., hard and soft hammers, saws) and a certain know-how. A range of techniques (flaking, sawing, drilling, pecking, grinding, and polishing) were employed and combined in diverse ways to form the tools.

When examining the published data, an interesting underrepresentation or complete absence of the technique of flaking is observed in edge tool assemblages from Southern mainland Greece, from the islands, and – to a lesser extent – from Central Greece. In these areas, edge tools are frequently formed through pecking and grinding, or even exclusively through grinding, on collected cobbles and pebbles that, in shape and size, closely resemble the intended final product. It is characteristic that Moundrea-Agrafioti (1996), who studied edge tools from a number of Thessalian sites, does not mention the technique of flaking as part of their manufacturing sequence. At the Franchthi site, only one specimen out of a set of 88 edge tools bears traces of this technique (Stroulia 2010), whereas, in the Neolithic material from Knossos, Crete, only two do so (Evans 1964, 229). Saliagos in the Cyclades (Boleti 2009, 221) and Ayios Vlasis in Central Greece (Chondrou, pers. obs.) exhibit a more intense application of flaking and can be considered intriguing exceptions.

In contrast, flaking is clearly more often attested in edge tool assemblages from Northern Greece (cf. Tab. 5)[7] although it is not uniformly applied in all assemblages or to the same stages of the tools' life-cycles. For instance, in Makriyalos, contrary to other northern sites, flaking – generally limited in its application (Tsoraki 2011, 236) – was rarely used at the initial stage of the reduction sequence, being primarily related to maintenance episodes instead (Tsoraki 2008, 64; Yerousi 1999, 61).

The uneven application of flaking cannot be attributed to the raw materials used (*contra* Perlès 2001, 233 Footnote 11). As mentioned, many settlements share a preference for similar rock types, such as serpentinite. Although considered unsuitable for shaping through flaking (see Stroulia 2010, 68), serpentinite has indeed been found to have been manipulated in this way in several Greek settlements (e.g., Kleitos, Western Macedonia, where the application of flaking is particularly extensive; Chondrou 2018). Thus, rather than viewing it as a consequence of raw material con-

7 Regrettably, documentation of this technique is frequently lacking in available publications: in the case of Stavroupoli, Central Macedonia, for example, flaking is mentioned as one of the tool shaping techniques without any further elaboration (Alisøy 2002, 567). Similarly, in the publication of Servia, the existence of a flaking stage in the manufacturing sequence of edge tools is merely suggested by the identification of a few flakes and fragments, without providing detailed references (Mould et al. 2000, 115; 117).

straints, the selective use of flaking should be interpreted as indicative of diverse cultural choices and technological traditions among prehistoric communities. The strong presence of flaking in the *chaînes opératoires* of Northern Greece may also hint at possible affinities with the north, since flaking is well-attested in the edge tool technologies of the Balkans throughout the Neolithic, where it was not only used for the shaping of preformed blanks but also for the production of the blanks themselves[8]. The latter process, namely, the use of flaking for the production of a flake or a blade to be shaped into a ground edge tool, proves so far to be a rarity in Greece, with a few examples documented, in the north, at Xirolimni, Toumba Kremasti Koilada, and Kleitos, Western Macedonia[9], in Central Greece, at Mandra, Thessaly (Chondrou, pers. obs.), in the Eastern Aegean, at Saliagos (Boleti 2009, 224), and in the south, at Knossos, Crete (Evans 1964, 186). Nevertheless, the scattered distribution of the known evidence suggests the possibility of more similar cases yet to be identified.

The application of sawing (Fig. 7) exhibits an interesting geographical distribution as well (cf. Tab 5). It is frequently attested in tool assemblages from the north – e.g., at Kleitos (Chondrou 2018, 92–94), at Megalo Nisi Galanis, Western Macedonia (Stroulia 2005, 573), at Varemenoi Goulon (Stroulia 2018a, 53–55), at Servia (Mould et al. 2000, 112–114), at Makriyalos (Tsoraki 2008, 60; Yerousi 1999, 35–37), at Avgi (Bekiaris 2018, 205–206), at Dispilio (Stratouli 2002, 161–162), at Nea Nikomedeia (Rodden 1962, 279), at Olynthus, Central Macedonia (Mylonas 1929, 75), and at Sitagroi (Elster 2003, 183; 185) – whereas it is notably absent in assemblages from the south (Neolithic Knossos represents an interesting exception). In Central Greece, sawing is quite rarely applied in edge tool manufacture – e.g., at Mandra (Chondrou, pers. obs.), at Sesklo (Moundrea-Agrafioti 1981, 183–184; Tsountas 1908, 314–315), and at Platia Magoula Zarkou, Thessaly (Stroulia 2022, 328) – and appears to be mostly associated with the formation of chisels – often through the segmentation of axes and adzes –, suggesting the existence of a specific correlation between technique and tool type (Moundrea-Agrafioti 1981, 232). A similar situation has been observed at some sites from Northern Greece as well: for example, at Servia, where many – if not all – minimal chisels of the assemblage were produced by splitting axes and adzes through sawing (Mould et al. 2000, 112–114), at Xirolimni, where a small group of thin elongated chisels was produced through multiple sawing episodes (Chondrou, pers. obs.), at Olynthus (Mylonas 1929, 75), and possibly at Sitagroi[10].

Another technique, drilling, was commonly used in the manufacturing of shaft-hole axes, i.e., edge tools with a perforation for the insertion of the haft into the body of the tool. The appearance and use of this tool type in Greece was, until quite recently, thought to have been associated with the Bronze Age period (Tsountas 1908; Moundrea-Agrafioti 1981; Moundrea-Agrafioti 1992). However, recent discoveries indicate that the origins of this technological innovation date back even earlier, to at least the LN period: two LN specimens from Sitagroi have been identified (Elster 2003, 178 Tab. 5,2), one LN specimen from Makriyalos (Tsoraki 2008, 66–67), five specimens from Kleitos in LN layers (Chondrou 2018, 134–137), and at least one LN specimen from Toumba Kremasti Koilada (Stroulia 2014, 66). Similar finds have been reported from Sesklo, Dimini (Tsountas 1908, 319–321) and Visviki Magoula (Bergner 2015, 498) in Thessaly, but their exact dating is uncertain. Furthermore, two specimens were found in Varemenoi Goulon (Stroulia 2018a, 60–61), but it is unclear from the published article whether they were surface finds or part of the excavation material, whereas the sole find from Koroneia is marked as Neolithic with no further details (Almasidou 2019).

The final manufacturing stages were that of grinding and polishing, both time-consuming and laborious. From a strictly functional perspective, the only part of the tool that requires polishing so that the tool is efficient is its edge. However, it is quite common to see grinding and polishing extending to other parts of the tool body, not infrequently throughout its entirety. Finds with meticulous grinding and polishing that obliterate all signs of previous manufacturing stages have in many cases sparked discussions about the symbolism expressed through aesthetics (see, for example, Stroulia 2010, 68–69).

In some instances, a correlation between raw material, size, and surface finishing has been noted. For example, in Neolithic Servia, small, medium, and large specimens are made of raw materials of increasing hardness but exhibit decreasing refinement of their surfaces. Thus, the superbly polished tools of less than 5 cm in length that are made of soft rocks differ greatly from the largest examples (11–20 cm in length) that are made of harder material and are often well-polished only in the area of the blade (Mould et al. 2000, 115). Similar observations have been made at Achilleion (Winn/Shimabuku 1989) and other Thessalian sites (Moundrea-Agrafioti 1981, 195–196).

Sometimes, certain areas of the tool surfaces (usually in the middle or two-thirds along the length of the tool or on and around the butt) are left untreated during the final stages of manufacturing in order to maintain a rough texture and, in this way, to facilitate the hafting of the tool. In other cases, tools receive pecking after polishing, so that rough patches are created for the same purpose. Notches, concavities on the narrow sides, and grooves perpendicular to the long axis of the tool are further indirect evidence for hafting detected in many assemblages (Fig. 8). Unfortunately, hafting in Aegean tool assemblages has not yet been thoroughly investigated through specialised studies. Nevertheless, it is more than certain that the forms of the hafts and the methods by which the stone tools were adjusted to them varied and had multiple dimensions beyond purely utilitarian/practical considerations (for eth-

8 E.g., Antonović 2008; Antonović 2014; Prinz 1988; Tringham et al. 1985; Voytek 1990.

9 Personal observation of the author, cf. also Chondrou 2011; Chondrou 2018; Chondrou 2022.

10 Although the published study does not provide specific references, an association of sawing marks and chisels is evident from the drawings, photographs, and artefact descriptions (see, for example, Elster 2003, 183 Fig. 5,20–21).

Fig. 7a–c Examples of tools with sawing marks: a chisel from LN Mandra, Thessaly, produced with sawing; b fragment of an edge tool with evidence of sawing from LN Kleitos, Western Macedonia; c small edge tool with unfinished sawing from EN Xirolimni, Western Macedonia.

Abb. 7a–c *Beispiele von Werkzeugen mit Sägespuren. a Durch Sägen hergestellter Meißel (Spätneolithikum, Mandra, Thessalien); b Fragment eines Schneidwerkzeuges mit Sägespuren (Spätneolithikum, Kleitos, Westmakedonien); c unfertig gesägtes, kleines Schneidwerkzeug (Frühneolithikum, Xirolimni, Westmakedonien).*

nographic studies that offer supporting evidence, see, for example, Hodder 1982; Pétrequin/Pétrequin 1993; for an extensive overview regarding the Asian Pacific region, see Buckley 2023).

From a broad perspective, it appears that the *chaînes opératoires* of the edge tools from Southern (and, to some extent, Central) Greece are less complex compared to those from the north. In these southern regions, the techniques of pecking and abrasion – the simplest methods for shaping a stone artefact – are predominantly used, whereas other techniques are infrequent or absent. Additionally, tools from the south often feature more curvilinear shapes, a result of limited intentional shaping of naturally rounded cobbles and pebbles. In contrast, edge tools from the northern parts of the country more often exhibit extensive shaping with complex *chaînes opératoires* that involve the combined application of various techniques and the expenditure of a significant amount of time and labour.

Neolithic edge tool technologies in Greece – discard and deposition practices

Use-wear analyses that would help us identify the functions of Greek Neolithic edge tools are lacking (see Christopoulou 1992 for an early first attempt which, unfortunately, was not followed up by other scholars). Therefore, inferences about the subject are drawn mainly on the basis of the size of the tools, the morphology of their edge, and their state of preservation. A general observation that can be made is that many edge tools present rich biographies with successive stages of use (not necessarily in the same activity) and regular intermediate maintenance episodes. Cases of reshaping, secondary use, or recycling have been documented in numerous assemblages. Often – but, interestingly, not always – these changes are a necessity imposed by accidental breakages that bring the previous use of the tools to an abrupt end.

Fig. 8a–c Examples of tools with evidence of hafting: pecking on a previously polished surface, groove, notches (a; c LN Kleitos; b EN Xirolimni, both Western Macedonia).

Abb. 8a–c *Beispiele von Werkzeugen mit Schäftungsnachweis: Hackspuren auf einer zuvor geschliffenen Oberfläche, Rille, Kerben (a; c Spätneolithikum, Kleitos, Westmakedonien; b Frühneolithikum, Xirolimni, Westmakedonien).*

Regarding the post-use manipulation of edge tools, information can be inferred through contextual analysis, co-findings, and preservation status. One form of recycling observed in several settlements is the incorporation of tools into various features. In terms of sheer numbers, perhaps the most impressive example of edge tool recycling comes from the site of Koroneia, Central Macedonia, where a group of 7 edge tools was uncovered during the cleaning and deconstruction of a single clay hearth (Almasidou 2019, 82). In Kleitos, an edge tool was found embedded in a circular clay platform, with no apparent functional role, as it was not part of either the substructure or the structure's floor. The large dimensions of the tool and its intact and fully functional state make the idea of accidental incorporation unlikely (Chondrou 2018). In Servia, an axe and two adzes were found incorporated into the walls of a Middle Neolithic (MN) building, another axe was incorporated into the floor of a thermal structure, and a few more specimens were found in the fills of pits and postholes (Mould/Wardle 2000, 44–51; Mould et al. 2000, 117). On the other hand, the discovery of two MN axes inside a pot at the same site (Mould/Wardle 2000, 37), as well as a unique hoard of 11 edge tools from MN Lerna, Peloponnese (Banks 2015, 51–52; 191), should probably be considered the result of storage practices.

In North-western Greece, a cluster of settlements exhibits similar methods of edge tool treatment, including deliberate fragmentation, burning, and interment in ditches and pits. Makriyalos (Tsoraki 2008), Kleitos (Chondrou 2018), Avgi (Bekiaris 2018), and Toumba Kremasti Koilada (Chondrou 2011; Stroulia/Chondrou 2013; Stroulia 2014) have all yielded finds that suggest the intentional manipulation of edge tools, among other tool types, beyond their primary function. Interestingly, they are all dated to the LN, suggesting the possible existence of contemporary shared beliefs at a regional level regarding the symbolic manipulation of these particular artefacts. At two of these sites, Kleitos and Makriyalos, a dual model of tool manipulation has been identified, with a differentiated treatment of grinding tools and edge tools, further reinforcing the idea of their function as symbols[11]. Additionally, the suggestion of the ritual breakage of axes has been made for Southern Greece in relation to the assemblages of the Alepotrypa and Franchthi Caves (Stroulia 2010; Stroulia 2018).

11 See also Hodder 1990; for ethnographic examples of tool-related symbolic and/or gendered representations, see Hamon/Le Gall 2011, 27; Lidström Holmberg 1998; Pétrequin/Pétrequin 1993; Taçon 1991.

Evidence for the deposition of edge tools in non-utilitarian spaces related to the dead is scarce and primarily found in the southern regions. Perhaps the clearest examples derive from the Neolithic cemetery of Aposelemis in central Crete and from the cave of Alepotrypa in the Peloponnese. In the first case, stone axes were found as grave offerings regardless of the gender and age of the deceased: a young male individual's burial was furnished with two stone axes, among other offerings, an older female individual's burial contained a small stone axe, and, lastly, the grave of an infant, the richest of the cemetery, was associated with a pit that contained 14 edge tools (Agelarakis/Kanta 2020). In the Alepotrypa Cave, of the 23 edge tools with contextual information available, ten were found in locations with a non-utilitarian function (e.g., areas of primary/secondary burials). They are all reported as bearing use-wear and are considered to be either utilitarian objects that ended their use-lives as offerings in special contexts or were used exclusively in such contexts (Stroulia 2018, 213). One find stands out from the rest both in terms of typology and context: a double-edged tool recovered from the bottom of a Final Neolithic (FN) pot that contained a human skull (Stroulia 2018, 213). A less straightforward association is found in the case of a stone axe from the fill above one of two recovered graves at the Ayioryitika settlement, Peloponnese (Petrakis 2002, 19). Lastly, in the case of the Sarakenos Cave, Central Greece, a higher concentration of tools (and other finds) was found in association with a human skeleton (Davri 2023). The rarity of such find-contexts reinforces the notion that edge tools, like other types of everyday ground stone tools, were not primary choices as offerings in funerary contexts in the Greek Neolithic.

Discussion

This article set out to provide a comprehensive overview of the key characteristics defining edge tool technologies across various regions of Greece during the Neolithic era. While this exploration is by no means exhaustive, the focus has been to delineate the principal technological patterns, both shared and divergent, that illuminate the cultural landscapes of Neolithic Greek communities.

The discernible technological traditions emerging from regional and supra-regional comparisons seem to document a north-south divide in the Greek territory. Taking into account the differences regarding the amount and type of data available from the north and the south, it can be said as a general observation that Northern Greece exhibits a penchant for more complex production of edge tools with more intricate biographies, characterised by frequent resharpening, reshaping, and instances of secondary use or recycling. Conversely, southern locales present tools with simpler *chaînes opératoires*, suggesting disparate approaches to tool production and utilisation. On the other hand, Central Greece, particularly the Thessalian region, appears to harbour a unique blend of technological characteristics, at the same time drawing influences from both southern and northern traditions.

While our understanding of Greek edge tool technologies continues to evolve, there is still a paucity of comprehensive data specific to individual geographical areas. North-western Greece is an exception: Here, due to the greater abundance of archaeological data and specialised studies, we can examine in more detail how the presence or absence of technological traits, as well as the presence or absence of characteristic and identifiable objects, may serve as indicators of contacts and exchanges between regions and traditions. From this point of view, the area north of the Thessalian plain is quite revealing: Certain sites display the prominent use of the flaking technique in edge tool production while at the same time lacking the characteristic Thessalian tool type A, whereas other sites exhibit the reverse picture. In the former case, an orientation towards the traditions of the north is indicated, whereas, in the latter case, the adoption of cultural elements from the south.

Looking ahead, as specialised studies on Aegean assemblages proliferate, a deeper, more nuanced understanding of edge tool technologies is to be anticipated. Future research endeavours, coupled with the application of innovative methodologies and analytical techniques, hold promise for unveiling hitherto unexplored facets of Greek edge tool technologies. All in all, this article has sought to provide a synthesised summary of the existing literature. Some ideas have been formulated and presented, more as food for thought than as conclusions of absolute certainty. Whether they will stand up to the scrutiny of future findings is unknown. What is certain, however, is that, as with many other categories of archaeological finds, edge tools testify to the richness and diversity of human civilization that never ceases to amaze us.

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Tab. 1 after Andreou et al. 1996

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Greenstone chisel-like adzes for carpentry were components of the »Neolithic Package« in Anatolia and the Balkans

Laura Dietrich, Mario Börner, Michael Brandl, and Barbara Horejs

Zusammenfassung

Meißelartige Grünsteindechsel für Zimmerhandwerk als Bestandteile des »neolithischen Pakets« in Anatolien und auf dem Balkan

Beile als unverzichtbare Werkzeuge der Landgewinnung und des Bauwesens werden seit langem als integraler Bestandteil des so genannten neolithischen Pakets im südwestasiatischen und europäischen Neolithikum angesehen. Aufgrund des uneinheitlichen Forschungsstandes, der Terminologie und der fehlenden Funktionsanalyse dieser amorphen Kategorie von Schneidwerkzeugen wird diese Annahme jedoch grundsätzlich pauschal als archäologische Fundkategorie – undifferenziert nach der tatsächlichen Verwendung dieser Werkzeuge – getroffen. In der vorliegenden Arbeit werden meißelartige Dechseln als neuer, eigenständiger Bestandteil des »neolithischen Pakets« technologischer Innovationen in Anatolien und auf dem Balkan vorgestellt – zwei der Regionen, die in den Veröffentlichungen von Beilfunden noch optimierbar ist. Meißelartige Beile, die, wie wir in dieser Arbeit gezeigt haben, ein besonderes Design haben, tauchen im Kerngebiet der Neolithisierung in der Levante auf, höchstwahrscheinlich im Anschluss an bedeutende Veränderungen in der Hausarchitektur – wie der Einführung von rechteckigem Holz und Holzverbindungen im Spätneolithikum. Obwohl die Erhaltung von Hausbauelementen aus organischen Materialien in den archäologischen Kontexten dürftig ist, kommen wir aufgrund von Form- und Gebrauchsspurenanalysen sowie laufenden Experimenten zu dem Schluss, dass wir es mit hochspezialisierten Zimmermannswerkzeugen zu tun haben, die in Anatolien und auf dem Balkan zusammen mit anderen Elementen des neolithischen Pakets nach Westen übertragen werden. Wir präsentieren eingehende funktionale, experimentell gestützte Analysen der Beile vom Çukuriçi Höyük, einer Pioniersiedlung an der westanatolischen Küste (ab ca. 6700 cal BC), und von Svinjarička Čuka auf dem Zentralbalkan (ab ca. 6000 cal BC), um die Besonderheit meißelartiger Beile innerhalb des Gerätespektrums und die Idee der Aufspaltung des Konzepts des »Neolithischen Pakets« in verschiedene Technologien zu sichern. Die beiden hier vorgestellten Fallstudien, die eine reiche Ansammlung meißelartiger Beile enthalten – zusammen mit wenigen anderen Beispielen an anderen Fundorten – weisen auf eine frühe Übernahme von architektonischen Elementen und Tischlerwerkzeugen in Westanatolien und auf dem Balkan als Schlüsselkonzepte des Wohnens während der Neolithisierung hin. Eine weitere – symbolische – Bedeutung spiegelt sich in den aufstrebenden Netzwerken des Austauschs von »Grünsteinen« in diesen Regionen als Rohmaterial für die Herstellung der spezialisierten Werkzeuge wider.

Summary

Axes, as essential tools for land clearance and construction, have long been considered an integral part of the so-called Neolithic package in the Southwest Asian and European Neolithic processes. However, due to the uneven state of research, terminology, and the lack of functional analysis of this amorphous category of cutting tools, this assumption is basically made as a whole, as an archaeological find category, and is undifferentiated according to the actual use of these tools. In the present paper we are introducing chisel-like adzes as a distinct component of the ›Neolithic Package‹ of technological innovations in Anatolia and the Balkans, two of the regions with a low state of the art in the publication of axe-assemblages. Chisel-like adzes which, as we have shown in this paper, have a particular design, emerge in the core area of the Neolithisation in the Levant most likely following significant changes in house architecture, like the introduction of rectangular timber and timber joints in the Late Neolithic. Although the preservation of house construction elements made of organic materials is poor in the archaeological contexts, we conclude, based on shape and use-wear analyses as well as on ongoing experiments, that we are dealing with highly specialised carpenter tools, which are transmitted towards the West, in Anatolia and the Balkans, together with other elements of the Neolithic package. We present in-depth functional, experimentally supported analyses of the axe assemblages of Çukuriçi Höyük, as a pioneer settlement on the West Anatolian coast (from c. 6700 cal BC), and of Svinjarička Čuka in the Central Balkans (from c. 6000 cal BC), in order to secure the distinctiveness of chisel-like axes within the axe assemblages and the idea of splitting the concept of ›Neolithic package‹ into distinct technologies. The two case studies presented here, including a rich assemblage of chisel-like adzes, together with fewer other analogues among other sites, indicate an early adoption of architectural elements and carpentry tools in western Anatolia and the Balkans as key concepts of home during Neolithisation. Another – symbolic – meaning is mirrored in the raising networks of »greenstone« exchange in these regions as raw materials for the production of the specialised carpenter tools.

Keywords Neolithic Package, chisel-like adzes, carpentry, Anatolia, Southeastern Europe

Schlagwörter Neolithisches Paket, meißelartige Dechseln, Zimmerhandwerk, Anatolien, Südosteuropa

Axes, adzes and chisels

Axes have long been seen as an integral component of the so-called Neolithic package – a sum of technological innovations enabling Neolithisation, like pottery, figurines, ›offering tables‹, M-shaped amulets, bracelets made of marble and stone, beads, bowls of ›greenstone‹ and phalli, grooved stones, chipped discs as well as polishers, belt hooks and bone *spatulae* (Özdoğan 2010; Özdoğan 2016; Çilingiroğlu 2005, 4 Tab. 1; Horejs 2019, 74 Fig. 2). Axes, adzes, and chisels, in the following labelled as Hitting and Cutting Tools (HCTs), are highly effective tools of a relatively simple and conservative, but efficient design, which undergo multiple changes in their use and meaning during the Neolithisation of different regions. Axes have a symmetrical shape, while adzes have one straight and one curved broadside, which is usually interpreted as indicating a difference in hafting (parallel with the shaft or perpendicular). Chisels are defined by their rectangular profile.

Axes (and adzes as well as chisels) are the main tools of the Neolithisation process. They are necessary for land clearance and the construction of houses and villages, and thus for the implementation of agriculture and settled life. Axes, adzes, and chisels are an early innovation of the core areas of the Neolithisation in Southwest Asia[1], being transferred from there to Anatolia[2] and on to Europe[3].

The new research presented here proposes a more detailed look at the other two components of the HCTs, the adzes and chisels, through analyses of the technologies of their production and use and through the identification of regional trajectories in connection with the Neolithisation process.

HCTs in the Levant and Upper Mesopotamia

The technological principle of the Neolithic axe is first attested in Southwest Asia, where at first small unpolished flint tools appear during the Pre-Pottery Neolithic A (PPNA), followed by larger polished ground stone axes in the Early PPNB (c. 9600–8000 BC), which acquire a shaft, successively transforming them into powerful hitting and cutting tools (Barkai 2005). During the Middle Neolithic (MPPNB/PPNC; c. 8000–7000/6900 BC) and the Late Neolithic (Pottery Neolithic: 7000/6400–5300 BC), large axes made from different lithic raw materials were already in wide use in the Levant (Barkai 2005; Dietrich 2018), Upper Mesopotamia (Davis 1982; Roodenberg 1986; Mazurowski 1997), and Central Anatolia (Wright et al. 2013)[4].

In a wider region throughout the core area of the Neolithisation, a general development from small to trapezoidal or oval large heavy polished cutting and hitting tools is evident between the PPNA and the PPNB. However, there is a major research bias between the southern Levant, where axes have been the object of intense studies and are published extensively (Barkai 2005; Barkai 2008), and Upper Mesopotamia and Anatolia, where only selected assemblages of a few sites have been analysed so far (Fig. 1)[5].

A second phase in the evolution of HCTs is marked by the »adze«, an innovation of the Pottery Neolithic. Following their appearance in site assemblages mostly after 7000 BC, adzes (and, in smaller numbers, chisels) will gradually replace axes until the Chalcolithic in the southern Levant (Barkai 2005; Barkai 2011). A few published assemblages from Upper Mesopotamia – for example, from Tell Sabi Abyad, Rakkah governorate, Syria (Huigens 2010), Bouqras, Deir ez-Zor governorate, Syria (Roodenberg 1983; Roodenberg 1986) and Shir, Hama governorate, Syria (Dietrich 2018) – with axes, adzes, and chisels may suggest a similar development. Thus, during the time coinciding with the Neolithic migration westwards, adzes are included in the innovation package of the Neolithisation in its core areas.

Terminological specifications on the types of »adze«

However, there are some terminological issues to be clarified here. Tools that have been labelled as »adzes« at Shir (Dietrich 2018, Pl. 1–2), »celts« at Sabi Abyad (Huigens 2010, Fig. 6–7; Huigens et al. 2014, 157, Fig. 6,5/60–63), or »*herminettes*« at Bouqras (Roodeberg 1983, Fig. 1,3,4,7)[6] have certainly few commonalities with the Central European »*Schuhleistenkeile*« or »*Flachbeile*« of the LBK (e.g., Willms 2012, Fig. 7; Elburg et al. 2015, Fig. 5), or the relatively large triangular or oval tools of the Southeastern European Neolithic (e.g., Antonović/Dimić 2021, 423–424 Fig. 4–5), to give just some examples – except for the hafting with the blade-transverse to the shaft.

The largest group of adzes at Sabi Abyad is composed of small tools with a length of up to 5 cm, but also a group of larger adzes is attested (Huigens 2010, Fig. 8–9). The small tools have one curved and one straight broadside with a rectangular or, more rarely, a triangular facet. The facet falls obliquely at a c. 45° wide angle on the blade, which seems to be a standardised pattern. Most of the adzes from Sabi Abyad are made from non-local, very hard rocks: dolerite at Sabi Abyad (Huigens 2010) and »greenstone« at Shir (Dietrich 2018). Tools that have been labelled as »adzes« in the southern Levant (Barkai 2005) are made of flint and are slightly larger than those in the northern Levant, with a facet on their straight side, which can be rectangular, triangular, or irregularly shaped. Chisels have facets similar to adzes.

At the moment of the Neolithic dispersal westwards, the toolkit of HCTs in the core area of this process was not only composed of axes, but also of (increasingly important) small adzes and chisels, following a presumed

1 Davis 1982; Wright 1994; Barkai 2005; Yerkes et al. 2012; Rosenberg/Gluhak 2016; Dietrich 2018.
2 Wright et al. 2013.
3 For example: Antonović 2003; Stroulia 2003; Tsoraki 2008; Nowak 2009; Müller-Beck et al. 2010; Weiner 1997; Weiner 2012; Ramminger/Šída 2012; Willms 2012; Elburg et al. 2015; Bernardini 2018; Masclans et al. 2021; Moník et al. 2021.
4 See also the comprehensive overviews on the material culture of the Neolithic in its core area: Kozłowski et al. 2006, 25 Map 2.2.5.4; Shea 2013, 233–238; 262–263 Fig. 7,21.
5 Davis 1982; Roodeberg 1986; Mazurowski 1997; Dietrich 2018.
6 See also type 6 of »*herminettes*« as well as some smaller exemplars of type 13 by Kozłowski et al. 2006.

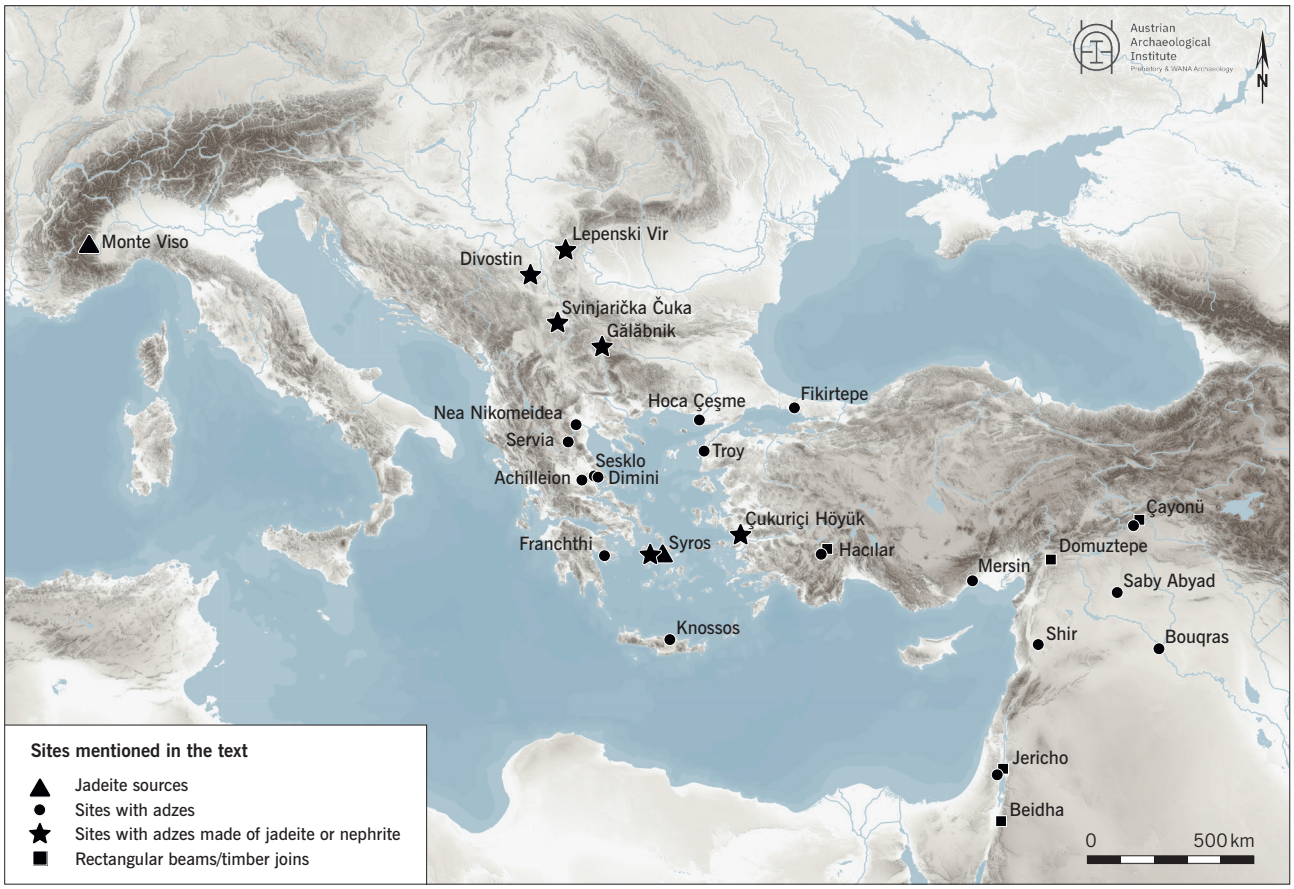

Fig. 1 Map with the location of the sites and finds discussed.

Abb. 1 *Karte mit den besprochenen Funden und -orten.*

change in woodworking practices as suggested by R. Barkai (2005; Barkai 2008). Barkai's interpretation of the »adze« innovation is mainly based on its versatility as a tool in comparison to the axes, as adzes are suitable for shaping or smoothing wooden planks, for the chopping and preparation of wooden utensils, and for other tasks in carpentry, in addition to tree-felling. Functional studies or reconstructions of hafting and handling are still missing for this category of tools, which probably explains their absence in the discourse on Neolithic technological innovations. However, adzes are transmitted with the Neolithic dispersion westwards and are, together with the axes, obviously common parts of site assemblages of the Neolithic pioneers in western Anatolia and South-eastern Europe. One of these pioneer sites is Çukuriçi Höyük near Izmir in western Anatolia, Türkiye.

HCTs in western Anatolia: The Neolithic site of Çukuriçi Höyük

The Early Neolithic site Çukuriçi Höyük (Fig. 2–3), excavated between 2006 and 2014[7], is one of the earliest Neolithic sites in western Anatolia and the Aegean (Horejs 2019). The tell settlement, which originally was situated in a shallow coastal inlet characterised by lagoons and swamps, was most probably founded by pioneer farmers coming up over the sea in an optimal micro-habitat for settling, farming, and herding (Horejs et al. 2015). The earliest domestic features, ^{14}C-dated to between 6680–6500 BC (ÇuHö XIII–XII), display an architecture composed of mud walls with massive post holes and plastered floors, whereas the successive Late Neolithic architecture (between 6500–5970 BC, ÇuHö XI–VIII) is built on stone wall foundations (cf. Fig. 3). Large houses with activity areas inside and outside, which stand on solid stone walls and are built of thick wooden posts, probably with wooden roofs and mud walls, have been reconstructed (Fig. 4; Brami et al. 2016; Lužnik-Jancsary et al. 2020). Thus, a rich wooden architecture can be reconstructed for Çukuriçi Höyük. The raw material came from the surrounding woods of deciduous oaks (Stock et al. 2013; Kayan 2014; Stock et al. 2015), which must have been exploited using HCTs. In fact, more than half (59 of 104) axes found at the site come from the Neolithic layers (Bochatz 2019). The rest of the finds belong to the later Chalcolithic and Bronze Age settlements that follow at Çukuriçi Höyük after a settlement hiatus or come from the mixed surface layer.

7 The excavation works were led by B. Horejs (Austrian Archaeological Institute, Vienna).

Fig. 2 Çukuriçi Höyük: View on the site during the excavations.

Abb. 2 *Çukuriçi Höyük: Fundort während der Ausgrabungen.*

Fig. 3 Çukuriçi Höyük: Examples of Late Neolithic house structures built on solid stone wall foundations – with mud walls and their activity areas.

Abb. 3 *Çukuriçi Höyük: Beispiele der spätneolithischen Hausstrukturen, welche auf soliden Steinmauerfundamenten errichtet wurden – mit den Lehmwänden und ihren Aktivitätsbereichen.*

The distribution pattern of Neolithic HCTs shows a dominance of the axes (symmetric section, 25 finds) in comparison with the adzes (one straight and one curved face, 12 finds). In addition, 2 chisels (narrow rectangular implements) and one pick-like implement have been observed. 9 fragments are probably from large axes but their attribution is not secured.

Following a traditional typological approach, a broad variety of shapes, ranging from oval to trapezoidal-elongate and trapezoidal-squat, rectangular-elongate and -squat, tri-

Fig. 4 Çukuriçi Höyük: Reconstruction of Late Neolithic house structures based on the interpretation of the archaeological contexts.

Abb. 4 *Çukuriçi Höyük: Rekonstruktion spätneolithischer Hausstrukturen auf der Grundlage der Interpretation der archäologischen Kontexte.*

angular or irregulate, in a variety of sizes, would have to be defined. However, this image is a result of the various deformation processes a tool can undergo between design, production, use, and recycling. A more reliable concept used in this study was to identify patterns of technological trajectories by analysing the complete *chaîne opératoires* of production, use, and maintenance of HCTs with special focus on the comparison between adzes and axes.

Rocks and »greenstones« at the site

There is a broad spectrum of rocks used to produce HCTs at Çukuriçi Höyük, which have been geologically and petrographically analysed in several studies (Wolf 2017; Sørensen et al. 2017; Schwall et al. 2020) and are the subject of current experimental projects for the determination of their mechanical properties related to their use as hitting and cutting tools.

Most of the Neolithic HCTs at the site (38 % = 29 finds) are made of locally available peridotite, which is a hard blackish rock and can be exploited in the near vicinity (Wolf 2017). Peridotite can be considered a good choice for the production of HCTs, as it is a dense and hard rock that can be transformed into sharp and heavy axes (for example, for tree-felling). Through the geological process of serpentinisation, parts of naturally occurring peridotite, an ultramafic rock, were hydrated and transformed into serpentinite, which, at Çukuriçi Höyük, has also been exploited for the production of HCTs. Serpentinite is considerably softer and not as resistant to breakage or pressure as peridotite, but it can also be more easily shaped and ground into axes or adzes. 13 % of the HCTs (10 tools) were produced of this medium-soft local rock. Other local rocks used in the production of HCTs are emery stones, which are very hard and abrasive; in the Neolithic settlement, they were used predominantly for the production of chisels. Emery stone was used to an almost similar extent as serpentinite (14 % = 11 tools). Amphibolite and basalt are only occasional choices (seven and three tools, respectively).

Surprisingly, almost a quarter (22 % = 17 tools) of the HCTs, mostly adzes, are produced from non-local rocks tentatively identified as jadeite through reflectance spectroscopy (Wolf 2017; Sørensen 2019; Schwall et al. 2020). This deep green rock is not only significantly harder than other lithic materials, but is also more resistant to breakage, fracture, and compression. Also, polished green HCTs made of jadeite have high aesthetic qualities, at least from a today's perspective.

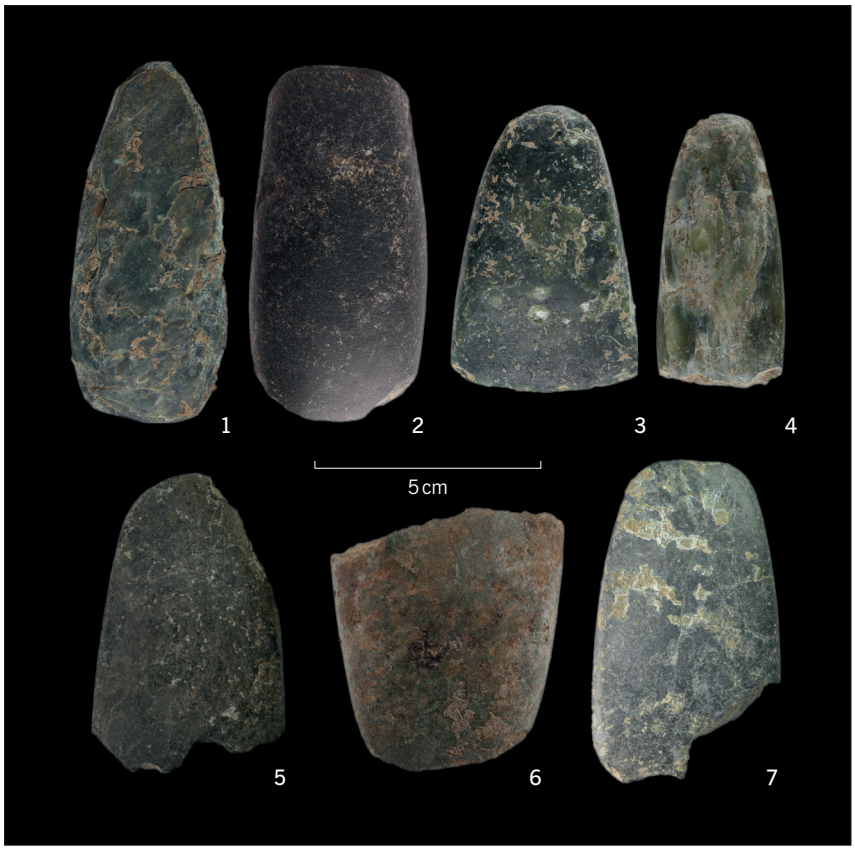

Fig. 5 Çukuriçi Höyük: The *chaîne opératoire* of production, use, maintenance, and recycling: model 1. 1–4 used axes made of peridotite, serpentinised peridotite, and emery stone; 5–7 broken, unrecycled fragments.

Abb. 5 *Çukuriçi Höyük: die* Chaîne opératoire *von Herstellung, Gebrauch, Instandhaltung und Wiederverwertung: Modell 1. 1–4 benutzte Beile aus Peridotit, serpentinisiertem Peridotit und Schmirgel; 5–7 zerbrochene, nicht wiederverwertete Fragmente.*

Our current projects follow the complex trajectories related to the exploitation, use, and exchange of »greenstone« in the eastern Mediterranean[8]. One of the tasks is to investigate the exploitation of jadeite in terms of use, frequency, affordance, and availability at the site. As has been previously observed (Schwall et al. 2020), Neolithic to Bronze Age Çukuriçi Höyük was embedded in a large network of exchange reaching up to almost 300 km in distance and including materials and products such as obsidian, volcanic rocks, and greenstone. At least some of the jadeite was transported from Syros, southern Aegean, Greece, as previous analyses have shown (Sørensen et al. 2017). For other jadeite artefacts, local resources and networks are assumed[9].

Modelling the chaîne opératoire *of use and usefulness*

The *chaîne opératoire* of production, use, and maintenance of the HCTs can be roughly divided into three models, which show divergent patterns for local and non-local materials but also for rocks of different qualities.

Model 1 is a pattern of production for hard, large (9–10 cm) and middle-sized (7 cm) axes from local rocks, mostly peridotite and emery stone (Fig. 5). Most probably, large- to middle-sized blanks already suitable for the desired tool were chosen from the vicinity of the site, flaked, and pecked into shape, as indicated by their production markers. They were used for different tasks and eventually discarded without any, or with only minimal, resharpening and recycling (cf. Fig. 5,5; Fig. 6–7). Their fragmentation pattern shows a relatively equal distribution of blades, body, or butt fragments.

The completely preserved axes have sharp blades and cutting edges. One use pattern of the large axes, observed on most tools, is characterised by regularly blunted blades covered with V-shaped fractures in the centre of the cutting edge and on its corners (cf. Fig. 6), as well as by asymmetrically rounded corners. The cutting edge also displays perpendicular and slightly oblique deep scratches and irregularly distributed medium reflective spots. Similar patterns have been observed on axes used for tree-felling (Fig. 7; Roy 2020, Fig. 8; 10). Wear markers on middle-sized axes are blades which are blunt and covered with either V-shaped or irregular fractures as well as oblique scratches and irregularly distributed spots which are medium to high reflective. The most frequent wear patterns observed on the analysed middle-sized axes are similar to the patterns on large axes, indicating their use as tree-felling tools. For all other middle-sized axes with divergent wear patterns, multifunctionality may be assumed. Work for house construction, for the procurement of fuel material, and for butchery was most probably performed with these tools. A large quantity of bones with deep large cut marks most likely produced by axes (Fig. 8; Galik 2019) comes from the Neolithic layers. Generally, archaeozoological research has reconstructed a diverse and extensive animal diet for the Neolithic inhabit-

8 Ongoing project led by L. Sørensen.
9 Ongoing project led by Sørensen.

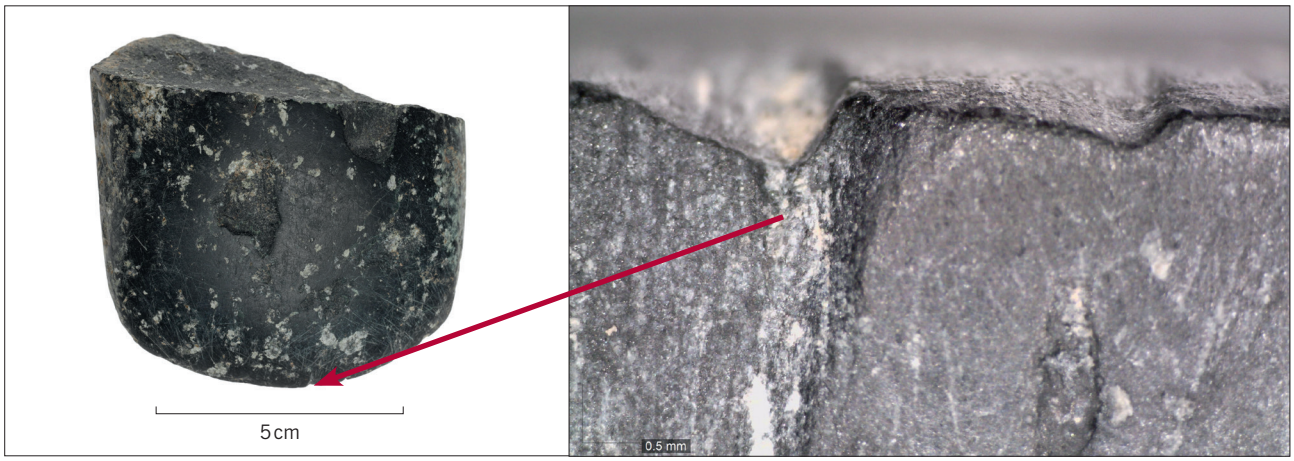

Fig. 6 Çukuriçi Höyük: Example of use-wear markers on massive axes: blunt bit with V-shaped fractures in the centre of the cutting edge.

Abb. 6 *Çukuriçi Höyük: Gebrauchsspuren an großen Beilen: stumpfe Schneide mit V-förmigen Brüchen in der Mitte der Schneidkante.*

ants of the site (Galik 2019), mainly based on domestic animals such as pigs, sheep, goats, and cattle, thus large animals for which butchery tools are required.

Our current experiments confirm the suitability of these kinds of axes for butchery on middle-sized animals (Fig. 9). In addition, axes can be effectively used to clean animal skins. Guided by the archaeological traces on bones, we used a toolkit composed of axes and flint blades to butcher a piglet weighing 15 kg. The use of axes makes the cracking of ribs and long bones easy; but axes are also much more suitable for cleaning animal skins of fat, a task that is nearly invisible in the archaeological record. However, the cleaning of one single pig skin, performed in 2023, did not leave enough significant evidence of wear to identify this use on the original tools.

Model 2 is a pattern of recycling larger jadeite or nephrite HCTs to be used as chisel-like adzes and chisels (Fig. 10). Most tools with this specific pattern are preserved as small green adzes with lengths between 2 and 4.5 cm. All adzes show multiple facets resulting from the recycling from larger tools and resharpening, such as sawing of their lateral sides, older grinding facets, and rudiments of older blades (Fig. 11).

These tools are made in a similar way and consist of an oval blade with a rectangular facet, inclined in a similar angle for all preserved tools. Striations on the facets, oriented parallelly and oblique to the cutting edge, and multiple small facets at their base indicate their manufacture and resharpening through grinding, until the desired edge shape was reached. In addition, one object[10] shows chipping as a manufacturing technique for the rectangular facets. The construc-

Fig. 7 Tree-felling experiments with axe replicas. In photo: Michael Brandl.

Abb. 7 *Experimentelles Bäumefällen mit Beilrepliken. Im Bild: Michael Brandl.*

10 Artefact No. 13_1722_03_002, cf. database of the project.

Fig. 8 Example of bone with cut marks found at Çukuriçi Höyük.

Abb. 8 *Beispiel eines Knochens mit Schnittspuren, gefunden in Çukuriçi Höyük.*

Fig. 9a–b Butchering of a pig. Experiments with axe replicas.

Abb. 9a–b *Schlachten eines Schweins. Experimente mit Beilrepliken.*

tion principles show similarities with the northern Levantine adzes from Sabi Abyad discussed above.

On the pieces from Çukuriçi Höyük, multiple cycles of resharpening and realigning of the angle of the rectangular facet can be observed (cf. Fig. 10,2–5; Fig. 12). The homogenic design and systematic resharpening indicate that we are dealing with highly standardised Neolithic tools for specific purposes. The use-wear observed on six completely preserved pieces is uniform: it consists of lines of regular U-shaped micro notches on the entire cutting edge, as well as of polish and perpendicular striations on the notches (cf. Fig. 12,5–6). Most probably, this pattern indicates a standardised use as a chisel-like tool, as has been observed in our (ongoing) experiments[11]. Both design and wear indicate a smoother handling than for axes. Most probably, as also suggested by their small size, chisel-like adzes were hafted in wood platelets or organic sleeves and used in a similar way to modern carpentry chisels of metal. These are manoeuvred through pushing the tool by hand into wood or using a soft hammer for precise cutting, trimming, or finishing, either of furniture, of planks (for wider tools) or of timber joints, which have to be cut precisely. This specific element of the house construction process is invisible in the archaeological record but must be considered in the functional interpretation of these tools.

Chisels, which are rectangular tools with blade designs similar to adzes, also including rectangular facets[12] and pen-like tools[13], which belong to the same recycling model, are rare. Both tools have considerably thinner blades than the adzes and hint at the probable existence of carpentry toolkits designed for high precision work.

The reasons for the choice of non-local jadeite to produce these specific tools cannot be easily investigated. Originally, in their first use life, most of the tools were likely either larger adzes or axes (cf. Fig. 11,1). Fragments of these tools are – in comparison with model 1 – only rarely preserved. This specific fragmentation pattern and the above-mentioned recycling traces on the smaller adzes are clear indicators of the recycling processes. Possibly, the specific hardness of jadeite, which is 7 on the scale of Mohs (e.g., Bradt et al. 1973, 727), and its resistance to breakage together with the possibility to produce sharp tools due to the high density and the fine-grained rock matrix could be the reason for recycling it into high-precision tools, a process that can also be observed in Sabi Abyad (Huigens 2010).

Model 3 refers to a model of production of small adzes or axes from local soft-green coloured stones (serpentinite) without or with only small traces of recycling, such as resharpening. Most likely, they were produced from water-

11 Project »WEAR« led by L. Dietrich/M. Brandl, forthcoming.

12 Artefact No. 14_2137_03_0009.

13 Artefact No. 13_1809_003_0001.

Fig. 10 Çukuriçi Höyük: The *chaîne opératoire* of production, use, maintenance, and recycling: model 2. 1 Adze; 2–5 adzes with traces of recycling and use; 6 adze with traces of recycling.

Abb. 10 *Çukuriçi Höyük: Die* Chaîne opératoire *von Herstellung, Gebrauch, Instandhaltung und Wiederverwertung, Modell 2. 1 Dechsel; 2–5 Dechseln mit Spuren von Wiederverwertung und Gebrauch; 6 Dechsel mit Spuren der Wiederverwertung.*

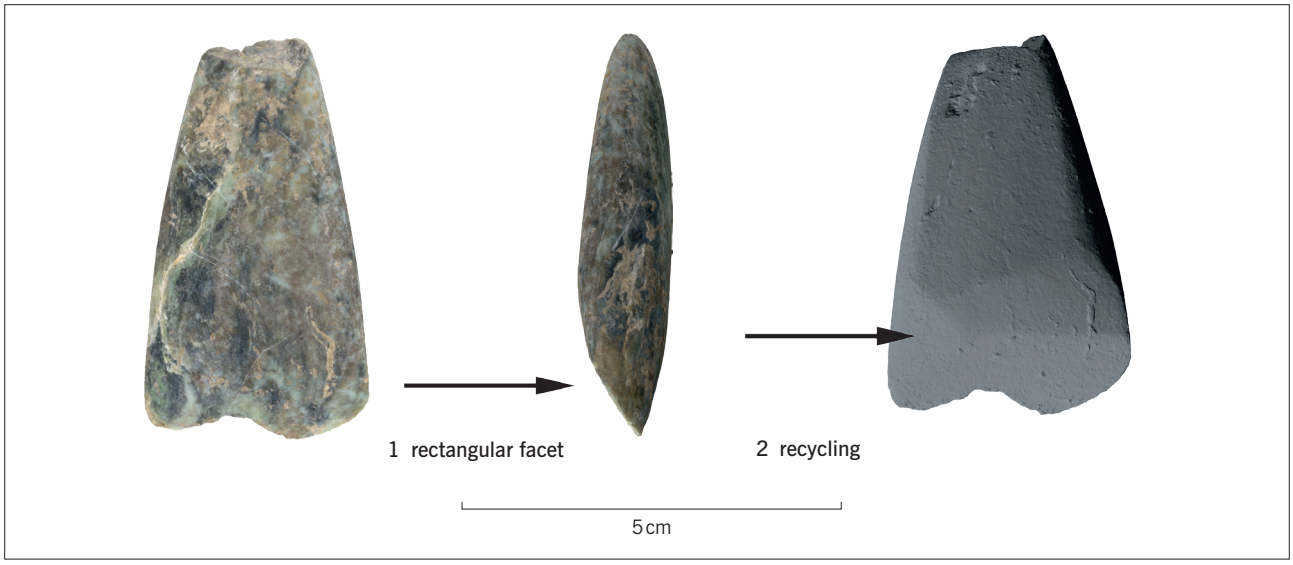

Fig. 11 Çukuriçi Höyük: Adze made of jadeite, example of production, recycling, and use-wear traces.

Abb. 11 *Çukuriçi Höyük: Dechsel aus Jadeit. Beispiel für Spuren von Herstellung, Wiederverwertung und Gebrauch.*

worn, serpentinised pebbles and cobbles. For example, one artefact[14] still bears waterworn natural surface remains, which were left untreated. This kind of production for small axes and adzes was also employed in the Early Neolithic Franchthi Cave (Stroulia 2003). In assemblage from this site, the numerous small greenstone adzes with rectangular facets display similar patterns of use. Whether these tools were recycled (with strong arguments in favour of this hypothesis) has been the subject of prolonged discussion (Stroulia 2003). These small, possibly recycled, greenstone tools dominate the assemblage and may indicate Neolithic architecture based on the use of carpentry tools outside the cave, where small Neolithic domestic structures are known (Jacobsen 1981). It also shows the transmission of this tradition from western Anatolia to Greece already in the Early Neolithic.

14 Artefact No. 14_2360_3-1.

Bringing the carpentry toolkit to the eastern Mediterranean and the Balkans

Green, small, hard chisel-like adzes with rectangular facets of the »Çukuriçi Höyük type« spread in the Neolithic of the eastern Mediterranean from Greece to Italy (see for example the HCTs in Sørensen 2019). They are not only made of jadeite, but also of serpentinite, and other until now unidentified/unanalysed greenish stones. Aside from the already mentioned tools from the Early Neolithic Franchthi Cave (Stroulia 2003), chisel-like adzes have been found at Early Neolithic Knossos (Strasser 2004) and Syros (Sørensen et al. 2017), as well as at the Early to Late Neolithic settlements of Nea Nikomeidea, Central Macedonia; Sesklo, Dimini, Achilleion, Tsangli, all Thessaly; Servia, Western Macedonia, as shown by C. Sugaya (2012, 67, Fig. 1). Chisel-like adzes are also attested in the Early Neolithic layers at Fikir Tepe in north-western Anatolia (Özdoğan 2023, 221 B2, B4, B9, B13, possibly B6) and in western Anatolia. The Neolithic tradition of the production of chisel-like adzes, largely made of hard and greenish stone, was most probably continued in the Chalcolithic and Bronze Age, both in Greece and in western Anatolia, where they are known from several sites (Sugaya 2012).

Thus, we can clearly identify chisel-like adzes made of greenish stones (of the Çukuriçi Höyük type) originating in the core area of the Neolithisation in the Northern Levant as an integral component of the Neolithic package in western Anatolia and Greece and the western Mediterranean during the »initial wave« (as proposed by Özdoğan 2019), in the Early Neolithic pioneer sites (Horejs 2019), but also later in the course of the establishment of settled life. From here, defined as a new core region of the Neolithisation in some models (Özdoğan 2019), chisel-like adzes of the Çukuriçi Höyük type were transmitted through different channels further north to the Balkans. They are attested at Early Neolithic Gălăbnik (Bakamska et al. 2018), where they are made of jadeite-omphacite and bear clear traces of recycling (Bakamska et al. 2018, 53 Fig. 3) to smaller tools; at Divostin, Šumadija district, Serbia (Antonović 2003, 91 Tab. 5; 94, Fig. 59,3–7), where they are presumably made of jadeite; at Early Neolithic Lepenski Vir, Serbia, where they are made of nephrite and serpentinite (Antonović 2003, 108 Fig. 68,3–5; 9; 12; 109 Fig. 69, 9–13; 104 Tab. 9; 106 Tab. 10); and at Early to Middle Neolithic Svinjarička Čuka, Lebane District, Serbia, where they are made of nephrite. Particularly the last site, which has been intensively investigated in recent years (Horejs 2019; Horejs et al. 2022), gives valuable insights into the process of transmission and local adaption of the Çukuriçi Höyük type of chisel-like adzes.

The case of Svinjarička Čuka (Serbia)

According to the latest ^{14}C dates (Horejs et al. in print), Svinjarička Čuka was already founded before or around 6000 BC, thus being one of the earliest pioneer sites in the Central Balkans. The archaeological site is situated on the elevated Svinjarička River terrace north-east of the famous Caričin Grad in the Lebane District of southern Serbia, and it is currently being investigated by an international and interdisciplinary research team within the framework of an Austrian-Serbian collaboration. A very important outcome of the research is the presence of solidly built architecture dating to the Neolithic Starčevo period (6000–5400 BC), representing the first agricultural communities along the Morava River connecting the Mediterranean cultures with the Danube region. The architectural structures are large rectangular houses attested through flat stones interpreted as sub-constructions of wooden poles and pit installations, stamped clay floors, and an oven in the interior. Consequently, the massive use of wooden constructional elements can be presumed, and the analyses of botanical taxa clearly supports this archaeological reconstruction (Schroedter in Horejs et al. 2022).

65 HCTs from the Neolithic, Chalcolithic, and the Bronze Age layers were found at the site. As has recently been observed (cf. the petrographic analyses in Brandl et al. in prep.), most of these tools were produced using locally available rocks, such as gneiss, quartz, quartzite, serpentinite, schist, and silicified siltstone. Clearly, most HCTs had been heavily used, especially in tasks implying hard impact on wood, such as tree-felling or woodcutting. The preliminary results of the use-wear analyses concur with the architectural reconstruction on the site. In addition, six HCTs were made of non-local nephrite and other non-determined green rocks.

There are clear differences in the *chaîne opératoires* of production, use, and discard of these HCTs compared to those of Çukuriçi Höyük, probably attesting to the adaptation to local environmental conditions. At Svinjarička Čuka, re-using and recycling was practiced in regard to the HCTs made of both local and non-local rock. Larger tree-felling axes made of local rocks as well middle-sized trapezoidal axes can be either repaired, recycled, transformed into smaller axes or discarded after breaking, while axes made of nephrite and green rocks can be recycled into hammers or adzes. However, the making of greenstone chisel-like adzes follows patterns similar to those in Çukuriçi Höyük, corroborating their affiliation to the spread of the Neolithic package described above: the pieces discovered until now are recycled from larger HCTs, are hard and small, and have similarly prepared rectangular facets (Fig. 12). Use-wear analyses indicate their use both for lighter tasks in carpentry, bearing similar wear markers as at Çukuriçi Höyük, and for heavier work, or for harder materials. Two of the analysed greenstone chisel-like adzes from the Early Neolithic layers display large breakages in the centre of the cutting edge, indicating impacts with high power, which would probably not correspond with light carpentry. To answer this question, future experiments are planned.

Greenstone chisel-like adzes continue to be present in the later Starčevo-Neolithic occupation at the site (5800–5500 cal BC) and in the layers of the Metal Ages. Their distribution coincides with the picture drawn by R. Kostov (2005) for artefacts made of nephrite in Neolithic and Chalcolithic Bulgaria. Obviously, this specific rock with qualities similar to the Aegean jadeite was used primarily for small adzes and chisel, and only secondarily for other artefacts.

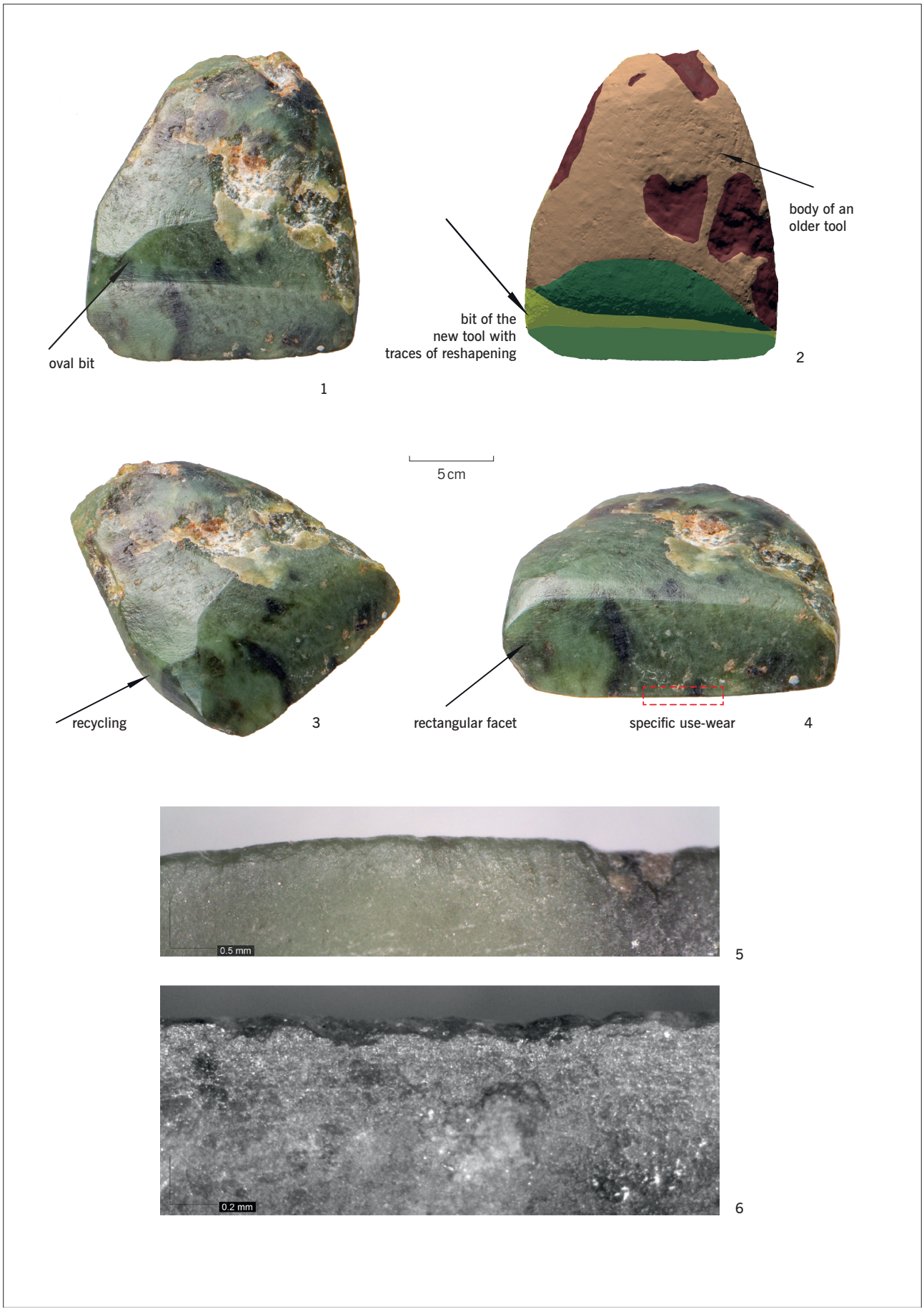

Fig. 12 Svinjarička Čuka: Adze made of nephrite with rectangular facet and traces of recycling.

Abb. 12 *Svinjarička Čuka: Dechsel aus Nephrit mit rechteckiger Facette und Spuren der Wiederverwertung.*

Current knowledge on the rising of Neolithic networks of jadeite, nephrite, and serpentinite

Jadeite

Until recently, the prevailing belief was that the sole prehistorically utilised jadeite deposits were confined to the Piedmontese Alps, specifically the Monte Viso source as detailed in studies by P. Pétrequin et al. (2012; Pétrequin et al. 2013). However, recent archaeological findings challenge this notion, shedding light on the existence of an additional jadeite source situated in the eastern Mediterranean, on the Cycladic island of Syros (Pétrequin et al. 2017; Sørensen et al. 2017). An origin of two jadeite axeheads within Çukuriçi Höyük's stone axe assemblage from Syros has been proposed by Sørensen et al. (2017, 502; 506–507), whereas the provenance of the remaining axes remains elusive except one specimen, which potentially could originate from a source in the Monte Viso region (Sørensen et al. 2017, 507). This assumption, however, was solely based on macroscopic examination and requires further instrumental testing, which is planned for the near future.

Nephrite

For the Balkan region, specifically Bulgaria, Kostov (2013, 14–15) established at least two distinct varieties of nephrite used for the production of axes and adzes, based on petrographic investigations. He also proposed the likelihood of two different source regions for the two macroscopically and microscopically differing types; however, to date they have not been located. This may be due to the fact that the deposits were entirely exploited already during prehistoric times, or that they may not be accessible anymore for various reasons, or that they have simply not yet been found (Kostov 2013; Kostov 2018). One particularly intriguing question concerns the predominant use of nephrite in the Balkan region compared to a dominance of jadeite in the eastern Mediterranean, including western Anatolia: an issue that requires further detailed studies. An ongoing project with Bulgarian collaborators focusing on central and eastern Balkan nephrite is expected to shed new light on the potential nephrite sources in the wider region[15].

Serpentinite

Regarding serpentinite distribution and use, and specifically the early stages of the underlaying networks, research is still in its incipient stages. It is therefore not possible to draw any conclusions, and we are only beginning to understand the significance of materials visually corresponding to what we term »green stone axes« in the context of the processes of Neolithisation.

Chisel-like adzes, carpentry, house construction, and exchange networks of green stones: New components of the »Neolithic package«?

This research puts the spotlight on three entangled phenomena emerging during the processes of Neolithisation, which must be approached in forthcoming investigations[16]:

1) The most important outcome of this study is the potential for the inclusion of adzes into the Neolithic package as a distinct component next to polished axes.

Following their invention in the Pottery Neolithic, beginning approximately in 7000 BC in the core area of the Neolithisation, adzes were regularly included in the Neolithic toolkit; from here, this specific tool was then transmitted with the Neolithic dispersal to western Anatolia together with other components of the Neolithic Package.

In some regions of the core area of the Neolithisation, adzes and chisel-like adzes seem to gradually replace axes in the Pottery Neolithic of the 7th millennium BC (Barkai 2005; Barkai 2011), but the state of research does not allow for a clearer picture at this moment. Chisel-like adzes are attested in western Anatolia at the earliest around 6700 BC at Çukuriçi Höyük and continued to be used in the Late Neolithic layers of the site (6500–6000 cal BC). They are also attested at Early Neolithic Fikir Tepe (Özdoğan 2023) and at the later phases in Hacılar, Mersin, and Troy (Sugaya 2012), suggesting a widespread technological tradition in South-west Asia.

Possibly through different pathways, via the Aegean and through north-western Anatolia (Özbek 2011; Reingruber 2011), the technological innovation was transmitted to southern Europe (to Crete, coastal Greece, Bulgaria, and Serbia, starting around 6700–6000 BC), where it is attested during the Early Neolithic, and later in the Middle and Late Neolithic up to the Chalcolithic, where adzes are well-represented in the toolkit (Antonović 2014). Here, a combined contextual and diachronic study of tool assemblages with use-wear analyses could provide more insights into the social and economic role of these tools in the Southeastern European Neolithic. Most probably, Europe's first specialised carpenters can be located in the Neolithic of Southeastern Europe.

2) The introduction of this specific tool was probably related to changes in Late (Pottery) Neolithic house construction. Although both experiments and use-wear are only indicatory for the functional interpretation as carpentry tools, there is some evidence of their development in relation with the use of timber joints in house construction. Already some PPNA–PPNB Neolithic sites have evidence of impressions of rectangular beams with worked surfaces, such as Çayönü, Diyarbakır province, Türkiye

15 For further information on the research project »Crossing the Neolithic Balkans. New approaches to green amulets«: <https://www.oeaw.ac.at/oeai/forschung/praehistorie-wana-archaeologie/prehistoric-phenomena/crossing-the-neolithic-balkans> (02.08.2024).

16 Ongoing project led by L. Dietrich.

Fig. 13 Vessel with depiction of houses from Domuztepe, Kahramanmaraş province, Türkiye.

Abb. 13 *Gefäß aus Domuztepe mit Darstellung von Häusern, Provinz Kahramanmaraş, Türkei.*

Fig. 14a–b Possible reconstruction of a chisel-like adze and its handling.

Abb. 14a–b *Mögliche Rekonstruktion eines meißelartigen Beils mit dazugehörigem Schaft.*

(Bıçakçı 2003, 390 Footnote 8), Jericho, Jericho governorate, Palestine (Kenyon 1981, 225), Beidha, Ma'an governorate, Jordan (Kirkbride 1984, 10), and Hacılar, Kayseri province, Türkiye (Mellaart 1970, 17 House P.1; Pl. 9,9; Pl. 58,7), which could be early evidence for timber joints using rectangular beams (especially at Beidha, where two rectangular beams have been found lying across each other: Kirkbride 1968, 92), or at least for the idea of working levelled surfaces on beams as elements for house construction. Possibly, the large-scale introduction of the chisel-like adzes during the Late Neolithic is an indication of the large-scale change to more stable timber joints in house architecture. The representation of houses on a Late Neolithic (Halaf Culture, c. 5800–5000 BC) vessel from Domuztepe, Kahramanmaraş province, Türkiye where such elements are clearly depicted (Fig. 13; Carter 2012, 112 Fig. 10a–b), could be considered clear evidence in spite of the otherwise poor preservation of the archaeological record.

Following this line of thought, we could ask ourselves to what extent the transmission of technologies and related practices in house construction were integrated into the local communities in western Anatolia, the Mediterranean, and Southeastern Europe as a key concept of the Neolithic home and of household societies.

3) The development of regional and supra-regional exchange networks of particular raw rock materials related to the production of HCTs and chisel-like adzes. The emerging evidence indicates a more complex jadeite and nephrite distribution network than previously assumed, involving more than one »master source« and, consequently, a more interconnected web of highly mobile agents in this socioeconomic framework (Horejs 2024). It is conceivable that materials with particular properties such as enhanced durability when compared to other rocks and with additional aesthetic characteristics gained importance beyond their primary utilitarian function. Implements manufactured from such special materials as jadeite and nephrite may thus have gained symbolic value and been symbolically charged (e.g., Skeates 2002). This might also explain why they were heavily reworked and recycled into other types and tools, sometimes at the lowermost limits of usability, rather than using such tools made from other types of rock.

Our future research[17] will focus on these topics. We are planning to carry out functional research on axes and adzes in several more Neolithic assemblages in the two regions, in addition to our focus on the experimental production (Fig. 14) and use of greenstone adzes in light of their role in Neolithic architecture and technologies. Our second research question is linked to the geological determination of the so-called greenstone in the archaeological assemblages of the Balkans and western Anatolia, a question with large potential.

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Authors contributions:

Laura Dietrich: direction and development of the study, conception and writing of the manuscript and conception of the figures, design of the documentation methods and documentation, functional analyses and the conducting of the experiments.

Barbara Horejs: direction of the excavation projects from Çukuriçi Höyük and Svinjarička Čuka, organisation of the data repository, creation of stratigraphy, dating and contexts, and comments on the text.

Mario Börner: documentation of the finds, comments on the text, design of the map with Laura Dietrich.

Michael Brandl: participation in the experiments, writing on the exchange networks, comments on the text and English proofs.

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Source of figures

1 after Horejs 2017, Fig. 1,2;
2 N. Gail, OeAI-OeAW
3 <https://defc.acdh.oeaw.ac.at/cukurici-movie/> (28.06.2024); Lužnik-Jancsary et al. 2020, 68 Fig. 3.
4 photos: N. Gail, OeAI-OeAW; compilation: L. Dietrich
5 photo: left N. Gail, OeAI-OeAW left and right L. Dietrich
6 photo: D. Hirako, OeAI-OeAW
7 photo: A. Galik, OeAI-OeAW
8 photo: above D. Hirako, OeAI-OeAW; below A. Haro, OeAI-OeAW
9 photos: N. Gail, OeAI-OeAW; compilation: L. Dietrich
10 photos: L. Dietrich, and D. Wieser, OeAI-OeAW; compilation: L. Dietrich
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12 Çiğdem Atakuman, METU Ankara
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14 photos: 1, 2 and left L. Baunack, MLU Halle-Wittenberg; 3, below L. Dietrich

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KUPFERZEIT

COPPER AGE

Kupferne Hammeraxt mit Verzierungen um das Schaftloch vom Typ Szendrő aus Prag (Praha-Strahov, Tschechische Republik). Der Typ datiert ins Frühäneolithikum, ca. 4400–3800 v. Chr. (s. Beitrag Dobeš in diesem Band).

Copper axe-hammer with decorations around the shaft hole of the Szendrő type from Praha-Strahov (Czech Republic). The type dates to the early Eneolithic, c. 4400–3800 BC (cf. Dobeš in this volume).

Metall zwischen Steinen – kupferne Äxte und Beile des böhmisch-mährischen Äneolithikums (ca. 4400 bis 2200 v. Chr.)

Miroslav Dobeš

Summary

Metal among stones – Copper axes of the Bohemian-Moravian Eneolithic period (c. 4400 to 2200 BC)

This paper deals with the Eneolithic heavy copper objects (flat axes, axe-hammers, adze-axes) that have been recorded or published so far (in Moravia as of 2019, in Bohemia as of 2017) in the Bohemian-Moravian Eneolithic (c. 4400–2200 BC). The current structure of the source material is briefly mentioned, and possible alternatives to the role of heavy copper objects in society at that time are commented on. The main part of the contribution is focused on a comprehensive evaluation of the available stock of finds, proceeding gradually through the four main stages of the Bohemian-Moravian Eneolithic (Initial, Early, Middle, and Late Eneolithic). Emphasis is placed on the chronological position of individual classes and types of finds, the relationship of the artefacts presented here to their contemporaneous environment in Central and Southeast Europe, and, in the context of their material composition, on the links to their presumed production centres (Transylvania, Slovakia, Eastern Alps). The Eneolithic evidence of the pyrotechnological processing of metal from the territory of the Czech Republic is also mentioned.

Keywords Bohemia, Aeneolithic, copper flat axes, hammer/cross axes, material groups

Zusammenfassung

In dem vorliegenden Beitrag werden die äneolithischen schweren Kupfergegenstände (Flachbeile, Hammer- und Kreuzäxte) behandelt, die bisher im böhmisch-mährischen Äneolithikum (ca. 4400–2200 v. Chr.) nachgewiesen bzw. veröffentlicht wurden (Stand für Mähren von 2019, für Böhmen von 2017). Kurz wird der aktuelle Quellenstand vorgestellt und mögliche Alternativen zur Rolle der schweren Kupfergegenstände in der damaligen Gesellschaft kommentiert. Der Hauptteil des Beitrags konzentriert sich auf eine umfassende Auswertung des verfügbaren Fundbestands, und zwar schrittweise in den vier Hauptetappen des böhmisch-mährischen Äneolithikums (Frühäneolithikum, Altäneolithikum, Mitteläneolithikum und Jungäneolithikum). Der Schwerpunkt liegt auf der chronologischen Stellung einzelner Fundklassen und -typen, dem Bezug der präsentierten Artefakte zum zeitgenössischen Fundumfeld Mittel- und Südosteuropas und im Kontext ihrer Materialzusammensetzung auch auf den Beziehungen zu einzelnen vermuteten Produktionszentren (Siebenbürgen, Slowakei, Ostalpen). Erwähnt werden auch äneolithische Belege der pyrotechnologischen Metallverarbeitung aus dem Gebiet der Tschechischen Republik.

Schlagwörter Böhmen, Äneolithikum, Kupferflachbeile, Hammer-/Kreuzäxte, Materialgruppen

1. Einleitung

Vor mehr als 10 000 Jahren begannen die Menschen im Nahen Osten, seltsame »Steine« zu sammeln. Im Gegensatz zu anderen zerfielen sie bei einem Schlag nicht, sondern veränderten ihre Form. Und wenn sie erwärmt wurden, ließen sie sich durch Schmieden noch leichter umformen. Bei sehr hohen Temperaturen flossen sie wie Wasser. Später hat man entdeckt, dass dieses Material bei hohen Temperaturen auch aus blau- und grünblaufarbigen Stücken gewonnen werden konnte, die genau dort vorgekommen sind, wo diese formbaren »Steine« – gediegenes Kupfer – gefunden wurden. Die ungewöhnlichen Eigenschaften haben das Material somit von Anfang an zu seiner Verwendung im symbolischen Bereich vorbestimmt. Von Anfang an wurden daraus nicht nur Schmuck (Özdoğan/Özdoğan 1999), sondern auch Prestigegüter hergestellt[1].

Die ersten Artefakte aus gegossenem Kupfer tauchten in der Alten Welt um 5000 v. Chr. auf. Dabei handelt es sich beispielsweise um Gegenstände aus dem Tell Yumuktepe in der Nähe der Stadt Mersin in der Südtürkei. Dort wurden nicht nur Schmuckstücke gegossen, sondern auch schwerere Gegenstände, in diesem Fall Flachbeile (Caneva 2000).

Wahrscheinlich nicht lange danach erlebte die Kupfermetallurgie auf dem Balkan einen großen Aufschwung. Davon zeugen nicht nur Hunderte von Kupferartefakten, sondern auch Kupferbergwerke. Anhand der Radiokarbondatierung von Geweihhacken aus den Schächten in Rudna Glava, Borski okr. (Serbien), könnten die Anfänge des Kupfererzabbaus dort schon in die ersten drei Jahrhunderte des 5. Jts. v. Chr. datiert werden (Pernicka u. a. 1993; Borić 2009).

In Mitteleuropa taucht eine größere Anzahl von Kupfergegenständen erst nach 4500 v. Chr. auf. In der Tschechischen Republik handelt es sich chronologisch gesehen um die jüngeren Stufen der Lengyel-Kultur. Böhmen und Mähren befinden sich zusammen mit Mitteldeutschland somit an der nordwestlichen Peripherie eines Produktions- und Distributionsnetzwerks, das auf metallenen Prestigegütern basiert und in engem Kontakt mit dem Distributionsbereich der Jadeitbeile, d. h. einer zeitgleichen westeuropäischen Form von Prestigegütern, steht (Pétrequin et al. 2010, 193).

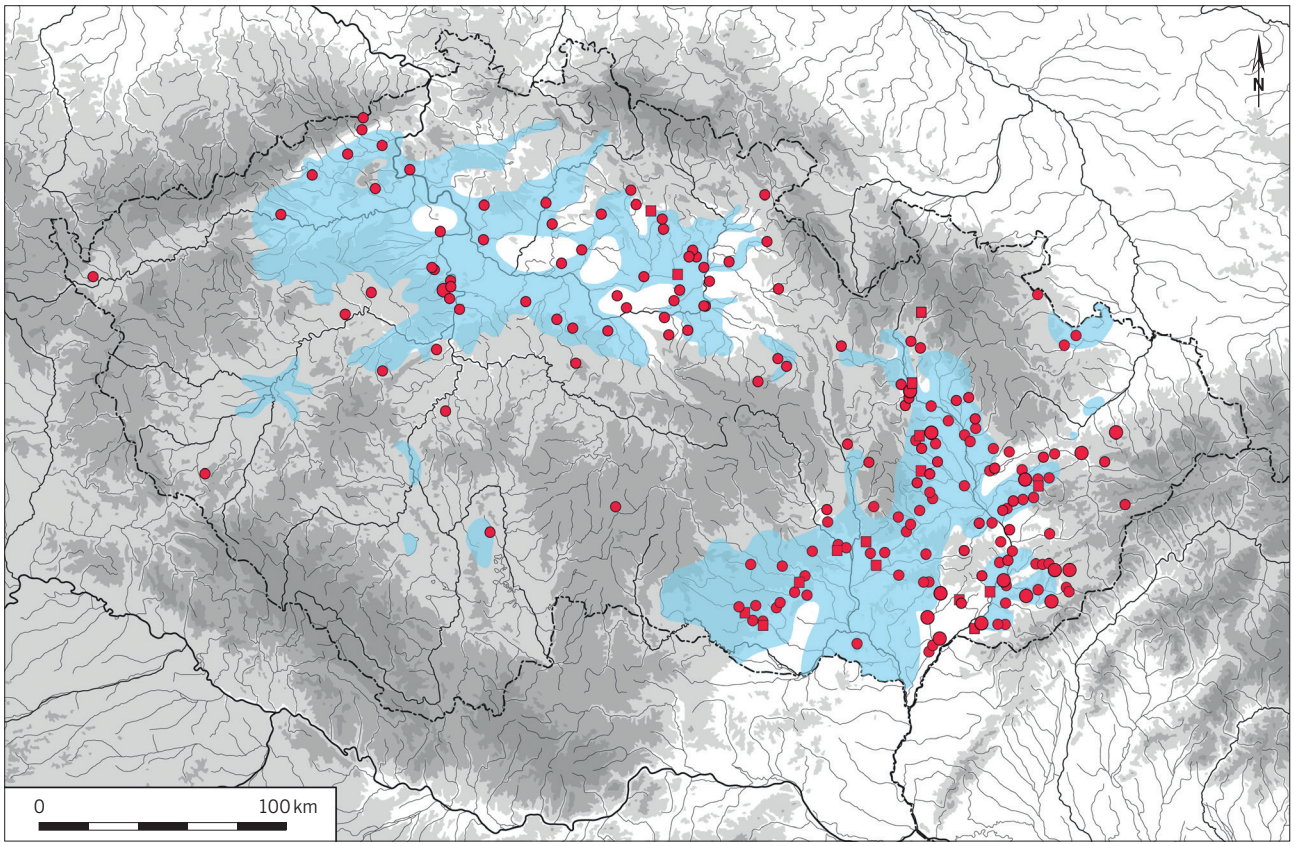

Abb. 1 Verbreitungskarte der äneolithischen kupfernen Äxte und Beile in der Tschechischen Republik (ca. 4400–2200 v. Chr.). Das sogenannte alte Siedlungsgebiet ist auf der Karte blau markiert; für Böhmen wurde die Siedlungsökumene bandkeramischer Kulturen verwendet, für Mähren die Ökumene mährischer bemalter Keramik. Kleinere Kreise weisen auf nur einen Fund aus der Katastralgemeinde (= Gemarkung) hin, größere Kreise auf mehrere Einzelfunde aus der Katastralgemeinde, Quadrate auf Hortfunde.

Fig. 1 *Distribution map of the Eneolithic copper axes in the Czech Republic (c. 4400–2200 BC). The so-called old settlement area is marked in blue; for Bohemia, the areas settled by Linear Pottery Cultures are used; for Moravia, the distribution area of Moravian painted pottery. Smaller circles denote one find from the cadastral area, larger circles several individual finds from the cadastral area, and squares stand for hoards.*

2. Quellenstand in der Tschechischen Republik

In der Tschechischen Republik verfügen wir derzeit aus dem gesamten Äneolithikum (ca. 4400–2200 v. Chr.) über ca. 230 Äxte und Beile unterschiedlicher Formen (Abb. 1). Etwa 80 % sind Flachbeile, der Rest besteht aus Hammer-, Kreuz- und Schafthalsäxten. Die Häufigkeit von Metallartefakten ist im Vergleich zu den aus Stein hergestellten Exemplaren ähnlicher Fundkategorien eher vernachlässigbar, da die steinernen Äxte und Beile in die Tausende gehen. So wurden allein an einer einzigen tschechischen äneolithischen Fundstelle, in Denemark bei Kutná Hora, okr. Kutná Hora, bei systematischen Ausgrabungen 148 ganze Exemplare und Fragmente geschliffener Steinartefakte und nur ein Kupferbeil entdeckt (siehe Zápotocký/Zápotocká 2008, 209–214; 254; 319; 321; Abb. 93–97; 130).

Die Kollektion von schweren Kupferartefakten besteht derzeit größtenteils aus Einzelfunden ohne weitere Fundumstände. Nur ein kleiner Teil stammt aus Hortfunden (ca. 15 %, am meisten aus Mähren); vier Artefakte wurden in einem mehr oder weniger zuverlässigen Siedlungskontext gefunden und eins stammt wahrscheinlich aus einem Grab[2].

3. Funktionale Interpretation schwerer Kupfergegenstände

Die einzigartige Beschaffenheit des Materials und das marginale Vorkommen im Vergleich zu steinernen Exemplaren ähnlicher Formen zeugen davon, dass Metallartefakte eher im symbolischen Bereich verwendet wurden (vgl. Strahm 2010; Neustupný 2013, 26), also beispielsweise für repräsentative und zeremonielle Zwecke oder als Votiv. Auf die Funktion als Weihgaben deuten beispielsweise die Funde in Bergregionen völlig außerhalb des Gebietes dauerhafter prähistorischer Besiedlung und die Funde aus Torfmooren hin (vgl. Abb. 1; Dobeš 2013, 36–37; Dobeš u. a. 2015, Abb. 2–3). In Betracht kommen auch andere Verwendungszwecke, z. B. als Prunkwaffen, wiederum mit dem Mehrwert einer Repräsentationsfunktion. Die Herstellung von Metallwerk-

1 Z. B. ein Keulenkopf aus der Fundstelle Can Hasan, Prov. Karaman (Türkei), aus der Wende vom 7. zum 6. Jt. v. Chr., siehe Yalçin 1997.

2 Für genaue Angaben zu allen Fundorten siehe die im Abbildungsnachweis von Abb. 1 zitierte Literatur.

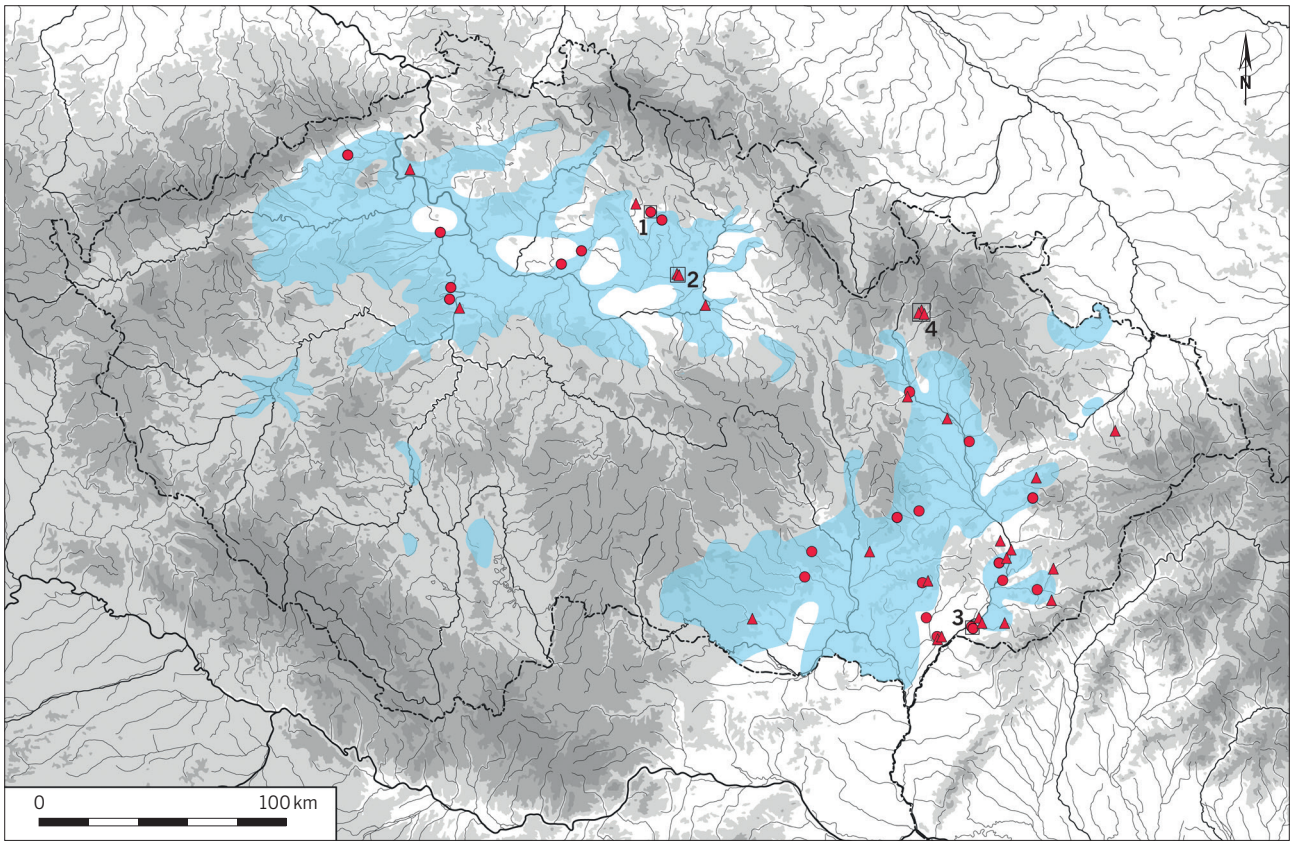

Abb. 2 Verbreitungskarte der kupfernen äneolithischen Hammer- und Kreuzäxte in der Tschechischen Republik (ca. 4400–3800 v. Chr.). Die Kreise deuten auf Hammeräxte und die Dreiecke auf Kreuzäxte hin. Hortfunde sind umrahmt: 1 Mlázovice, okr. Jičín; 2 Roudnice, okr. Hradec Králové; 3 Strážnice, okr. Hodonín; 4 Velké Losiny, okr. Šumperk. Für weitere Erläuterungen siehe Abb. 1.

Fig. 2 *Distribution map of the Eneolithic copper axe-hammers and adze-axes from the Czech Republic (c. 4400–3800 BC). Circles denote axe-hammers, triangles adze-axes. Hoards are circumscribed. 1 Mlázovice, Jičín district; 2 Roudnice, Hradec Králové district; 3 Strážnice, Hodonín district; 4 Velké Losiny, Šumperk district. For additional explanations, see Fig. 1.*

zeugen im mitteleuropäischen Äneolithikum ist jedoch mehr als zweifelhaft. Die dominanten Rohstoffe für deren Erzeugung blieben nach wie vor Stein, Knochen, Holz usw.

4. Frühäneolithikum (ca. 4400–3800 v. Chr.)

Den ersten schweren Kupfergegenständen begegnen wir in Böhmen und Mähren etwa um die Mitte des 5. Jts. v. Chr. Es handelt sich meist um Einzelfunde, deren chronologische Einordnung nur aufgrund formaler Ähnlichkeiten mit besser datierten Exemplaren im Karpatenbecken oder auf dem Balkan möglich ist. Die Klassifikation der Hammer- und Kreuzäxte basiert bis heute auf einem Artikel von F. Schubert (1965), der später von verschiedenen Autoren in Details modifiziert wurde (z. B. Patay 1984; Heeb 2014). Am Anfang der typologischen Reihe sollten also Hammer- und Kreuzäxte ohne Schaftlochfortsatz stehen (Typen Pločnik, Čoka und Mugeni), wonach die Exemplare mit Schaftlochfortsatz folgen (Hammeräxte der Typen Holíč, Kežmarok, Mezőkeresztes, Székely-Nádudvar; Kreuzäxte der Typen Jászladány und Nógrádmarcal). Das Vorkommen von kupfernen Hammeräxten im böhmisch-mährischen Äneolithikum endet mit den Exemplaren mit brettförmigem Rumpf (Typen Handlová, Szendrő), wenn man von dem Einzelfund des Typs Eschollbrücken aus Lužice, okr. Hodonín, absieht (siehe unten).

Chronologisch gesehen dürften die ersten Hammer- und Kreuzäxte etwa um die Mitte des 5. Jts. v. Chr. vorkommen (das Ende der mährischen bemalten Keramik), die zweite Gruppe am Ende desselben Jahrtausends (die Jordansmühler Kultur) sowie die Typen Handlová und Szendrő kurz nach 4000 v. Chr. (Epilengyel mit dem Vorkommen der Furchenstichkeramikkultur und Schussenrieder Gruppe). Der früher zunächst deklarierte chronologische Zusammenhang der Hammeräxte des Typs Handlová mit der Badener Kultur (Novotná 1974, 13–14; Schubert/Schubert 1999, 666–668) erscheint höchst unwahrscheinlich (dazu schon Točík/Bublová 1985, 87).

Aus Böhmen und Mähren wurden bisher 22 Hammeräxte veröffentlicht (Abb. 2). Wie üblich handelt es sich meist um Einzelfunde, in zwei Fällen um Hortfunde[3].

3 Mlázovice, okr. Jičín, in Böhmen und Strážnice, okr. Hodonín, in Mähren; Schubert 1965, Abb. 2,5; Říhovský 1992, 26; Taf. 1,8.

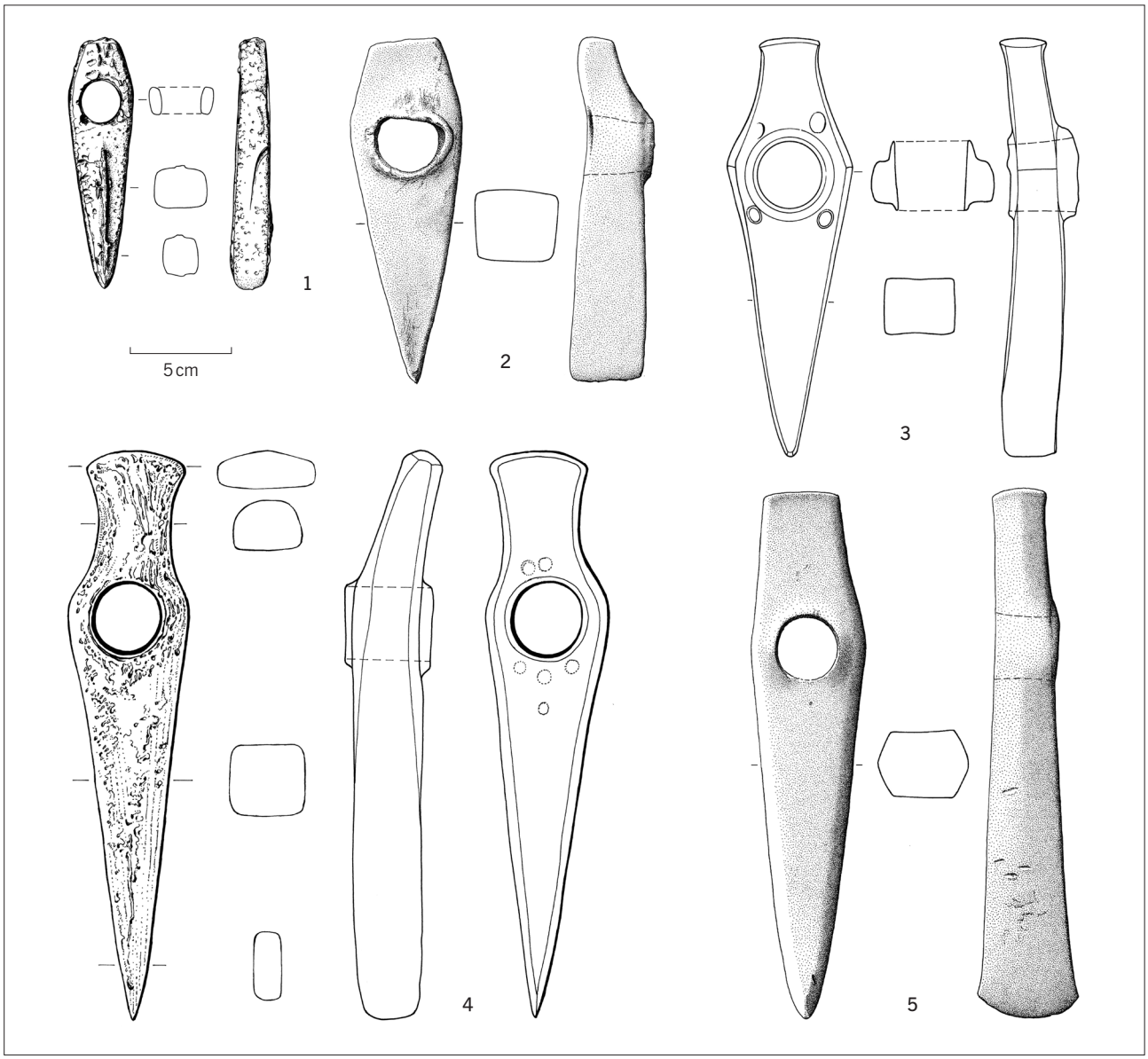

Abb. 3 Kupferne Hammeräxte (ca. 4400–3800 v. Chr.). Fundauswahl. In Klammern hinter der Fundstelle wird der Typ des Artefakts angegeben. 1 Olomouc-Holice, okr. Olomouc (Pločnik); 2 Praha-Podbaba (Kežmarok); 3 Mlázovice, okr. Jičín (Székely-Nádudvár); 4 Mohelnice, okr. Šumperk (Mezőkeresztes); 5 Dvory, okr. Nymburk (Holíč).

Fig. 3 *Copper axe-hammers (c. 4400–3800 BC). Selection. The type of artefact is given in parentheses after the site of discovery. 1 Olomouc-Holice, Olomouc district (Pločnik); 2 Praha-Podbaba (Kežmarok); 3 Mlázovice, Jičín district (Székely-Nádudvár); 4 Mohelnice, Šumperk district (Mezőkeresztes); 5 Dvory, Nymburk district (Holíč).*

Als die ältesten können wir die Hammeräxte vom Typ Pločnik betrachten, die in allen Fällen bisher nur in Mähren entdeckt wurden[4]. Die meisten kupfernen Hammeräxte aus Böhmen und Mähren gehören zu den typologisch weiterentwickelten Varianten mit Schaftlochfortsatz (Beispiele siehe auf Abb. 3). Der stilistische Endtyp Szendrő ist bisher nur durch zwei Exemplare aus Böhmen belegt (Abb. 4).

Etwas häufiger als Hammeräxte sind im Untersuchungsgebiet die Kreuzäxte anzutreffen (vgl. Abb. 2). Während in Mähren der Typ Jászladány eindeutig vorherrscht[5], ist aus Böhmen eher der Typ Nógrádmarcal belegt[6]. Ähnlich wie bei Hammeräxten handelt es sich hierbei meist um Einzelfunde, Horte sind bisher nur zweimal bekannt. Einer von ihnen wurde in der Nähe von Velké Losiny, okr. Šumperk, im Norden Mährens entdeckt, bereits außerhalb des alten Siedlungsgebietes, und ist daher wahrscheinlich als Hinweis des Kommunikationsnetzes zwischen Mähren und Schlesien anzusehen. Er besteht aus drei Kreuzäxten vom Typ Jászladány (Abb. 5,1–3). Der zweite Hortfund, jener aus Roudnice, okr. Hradec Králové, ist wegen seiner einzigartigen Kombination von Kreuzäxten der Typen Jászladány und Nógrádmarcal interessant (vgl. Abb. 5,4–5).

4 Beispiel auf Abb. 3,1; insgesamt 4–5 Stück: Říhovský 1992, 22; 24; Taf. 1,1–3.6; Dobeš/Peška 2010.

5 Zwölf Exemplare im Vergleich zu drei vom Typ Nógrádmarcal, fünf Fragmente sind typologisch unbestimmbar.

6 Vier von insgesamt sechs Exemplaren, für Beispiele für beide Typen siehe Abb. 5.

Abb. 4 Kupferne Hammeräxte vom Typ Szendrő (ca. 4000–3800 v. Chr.). 1 Praha-Strahov; 2 Mlčechvosty-Vepřek, okr. Mělník.

Fig. 4 *Copper axe-hammers of the type Szendrő (c. 4000–3800 BC). 1 Praha-Strahov; 2 Mlčechvosty-Vepřek, Mělník district.*

Die Hortfunde von Metallartefakten aus diesem Gebiet Europas bestätigen immer wieder das Vorkommen von kupfernen Flachbeilen schon mindestens seit dem Horizont der ältesten kupfernen Hammer- und Kreuzäxte (vgl. Antonović 2014, 21; 37–41; Taf. 55–58; Chernakov 2018). Ihre Klassifizierung ist äußerst uneinheitlich und es werden im Grunde selbständige typologische Systeme für einzelne Länder oder Regionen erstellt[7]. Für die Tschechische Republik wurde ein System entworfen, das alle äneolithischen kupfernen Flachbeile in drei typologische Hauptgruppen einteilt[8]. Anschließend wurde es weiter modifiziert (Klassen u. a. 2011; Dobeš 2013, 29–30; Dobeš et al. 2019, 31–33).

Die erste typologische Gruppe von Flachbeilen, die zeitlich ins Frühäneolithikum fällt, zeichnet sich durch ein deutliches Missverhältnis zwischen Breite und Länge aus, wodurch die Beile eher schmalen Keilen ähneln. Ein weiteres wesentliches Merkmal ist ihre beträchtliche Stärke, mit der sie offenbar formal an die steinernen Vorlagen anknüpfen. Diese Gruppe kann man weiter in drei Unterformen gliedern, nämlich in ungefähr rechteckige Beile (Typen Pločnik, Stollhof, Hartberg usw.), dreieckige Beile (Typen Kaka/Treuen, Rödigen usw.) und Flachbeile mit deutlich ausladender Schneide (Typen Jordanów, Osík usw.). Die simple Form der Flachbeile macht es oft schwierig, den konkreten Typ des Artefakts zu bestimmen; dieser kann oft nur durch ihre Kombination definiert werden (Beispiele für diese Beile siehe Abb. 6).

Die Flachbeile der ersten typologischen Gruppe stellen die zahlenmäßig stärkste Gruppe von äneolithischen schweren Kupferartefakten dar. Insgesamt wurden bisher etwa 90 Exemplare veröffentlicht (Abb. 7). Nur in zwei Fällen kommen sie in Horten vor. Der erste Hortfund, jener aus Vracov, okr. Hodonín, bestand aus drei kupfernen Flachbeilen vom Typ Jordanów (Říhovský 1992, 58; Taf. 8,68–69). Der Hortfund von Nedakonice, okr. Uherské Hradiště, enthielt zwei kupferne Flachbeile, einen Meißel und ein Artefakt, das als ein kupferner Rohling/Gussbarren interpretiert werden kann (Abb. 8).

Der Gussbarren aus Nedakonice könnte die lokale Produktion zumindest eines Teils der typologischen Skala frühäneolithischer Kupferartefakte sowie das Vorkommen bestimmter Typen belegen. Im Untersuchungsgebiet tauchen in dem Fundgut zum Beispiel Artefakte auf, für die wir entsprechende Vorlagen nicht im Karpatenbecken und weiter südöstlich, sondern in den aus Stein gemachten Exemplaren im Westen finden. Dabei handelt es sich um dreieckige Kupferflachbeile vom Typ Rödigen und andere (vgl. Abb. 7), die in ihrer Form eindeutige Ähnlichkeiten mit spitznackigen Beilen aus alpinem Jadeit aufweisen (siehe Pétrequin u. a. 2010; Klassen u. a. 2011). Die lokale Herstellung von Kupferartefakten wurde kürzlich durch die Entdeckung eines Schmelztiegels mit Spuren von Kupfer in Rousínov-Rousínovec, okr. Vyškov, bestätigt. Der Schmelztiegel wurde im Kontext der Jordansmühler Kultur gefunden und kann daher etwa auf das Ende des 5. Jts. v. Chr. datiert werden (Šmíd u. a. 2016).

Nach dem aktuellen Forschungsstand, der vor allem von Analysen zur Zusammensetzung der Kupfergegenstände ausgeht, lassen sich drei Materialgruppen identifizieren. Eine große Gruppe von Artefakten besteht aus Exemplaren aus nahezu reinem Kupfer, das höchstens Hundertstel Prozent anderer Elemente enthält, am meisten Silber[9]. Beide Kupfertypen (E00 und N) unterscheiden sich nur geringfügig voneinander, die Quelle beider Gruppen könnte reines

7 Vgl. entsprechende Passagen in verschiedenen Bänden der Publikationsreihe Prähistorische Bronzefunde, Abteilung IX.

8 Dobeš 1989, unter Verwendung der Klassifikation nach Mayer 1977 und Kuna 1981.

9 Kupfertyp N oder E00 des Stuttgarter Labors, Junghans u. a. 1960, 71–74; 210 Tab. 2.

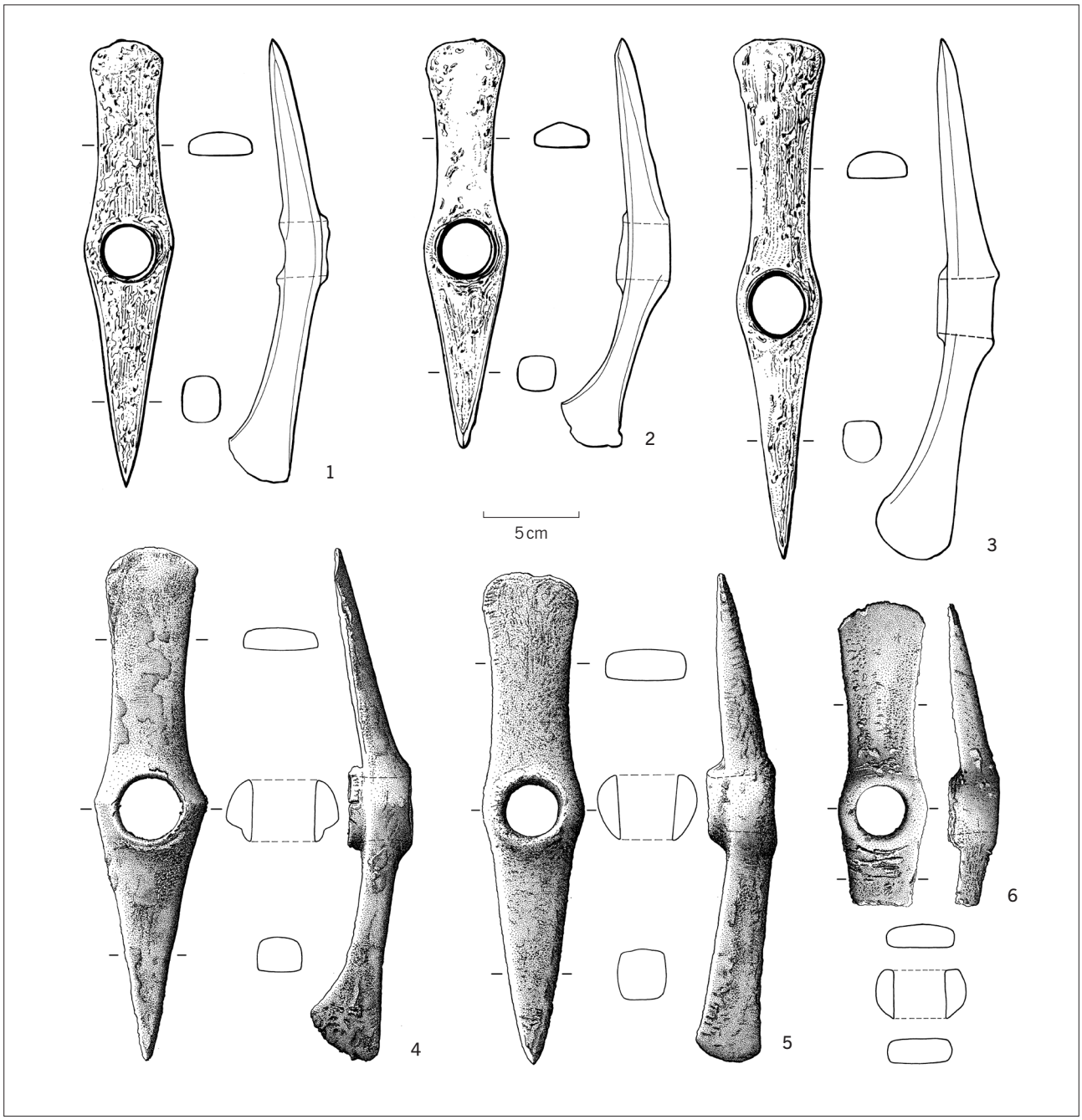

Abb. 5 Kreuzäxte (ca. 4400–3800 v. Chr.). Fundauswahl. In Klammern hinter der Fundstelle wird der Typ des Artefakts angegeben. 1–3 Velké Losiny, okr. Šumperk, Hortfund (Jászladány); 4–5 Roudnice, okr. Hradec Králové, Hortfund (4 Jászladány, 5 Nógrádmarcal); 6 Litoměřice, okr. Litoměřice (Nógrádmarcal).

Fig. 5 *Adze-axes (c. 4400–3800 BC). Selection. The type of artefact is given in parentheses after the site of discovery. 1–3 Velké Losiny, Šumperk district, hoard (Jászladány); 4–5 Roudnice, Hradec Králové district, hoard (4 Jászladány, 5 Nógrádmarcal); 6 Litoměřice, Litoměřice district (Nógrádmarcal).*

Metall aus der Erdoberfläche gewesen sein, von dem alle Kupfererzaufschlüsse in großem Maße begleitet wurden (Pernicka 1990, 27). Das Metall der angegebenen Parameter weist somit nicht eindeutig auf eine bestimmte Quelle hin (vgl. Heeb 2014, 80–82; Fig. 62) und seine Herkunft muss daher immer in Bezug auf einzelne Artefaktgruppen bewertet werden.

Im Untersuchungsgebiet gehören zu der angegebenen Materialgruppe 40 analysierte schwere Kupfergegenstände. In Mähren sind es alle analysierten Hammeräxte, fast alle Kreuzäxte vom Typ Jászladány und etwa zehn Flachbeile verschiedener Typen (Dobeš u. a. 2019, Tab. 1–2). In Böhmen ist die Situation nicht so eindeutig. Die Materialgruppe E00 ist zwar bei den beiden Kreuzäxten vom Typ Jászladány, aber nur bei zwei der sieben analysierten Hammeräxte und nur zwei von insgesamt 20 Flachbeilen nachgewiesen (Dobeš 2013, Tab. 2; 4; 6; Dobeš u. a. 2015, Taf. 1).

Die Kreuzäxte vom Typ Jászladány sind vor allem in der Großen Ungarischen Tiefebene und in Siebenbürgen weit verbreitet (Heeb 2014, 129; Map 4), wobei auch dort ihre Zusammensetzung in den meisten Fällen den Materialgruppen N oder E00 entspricht. Daher werden die Rohstoffquel-

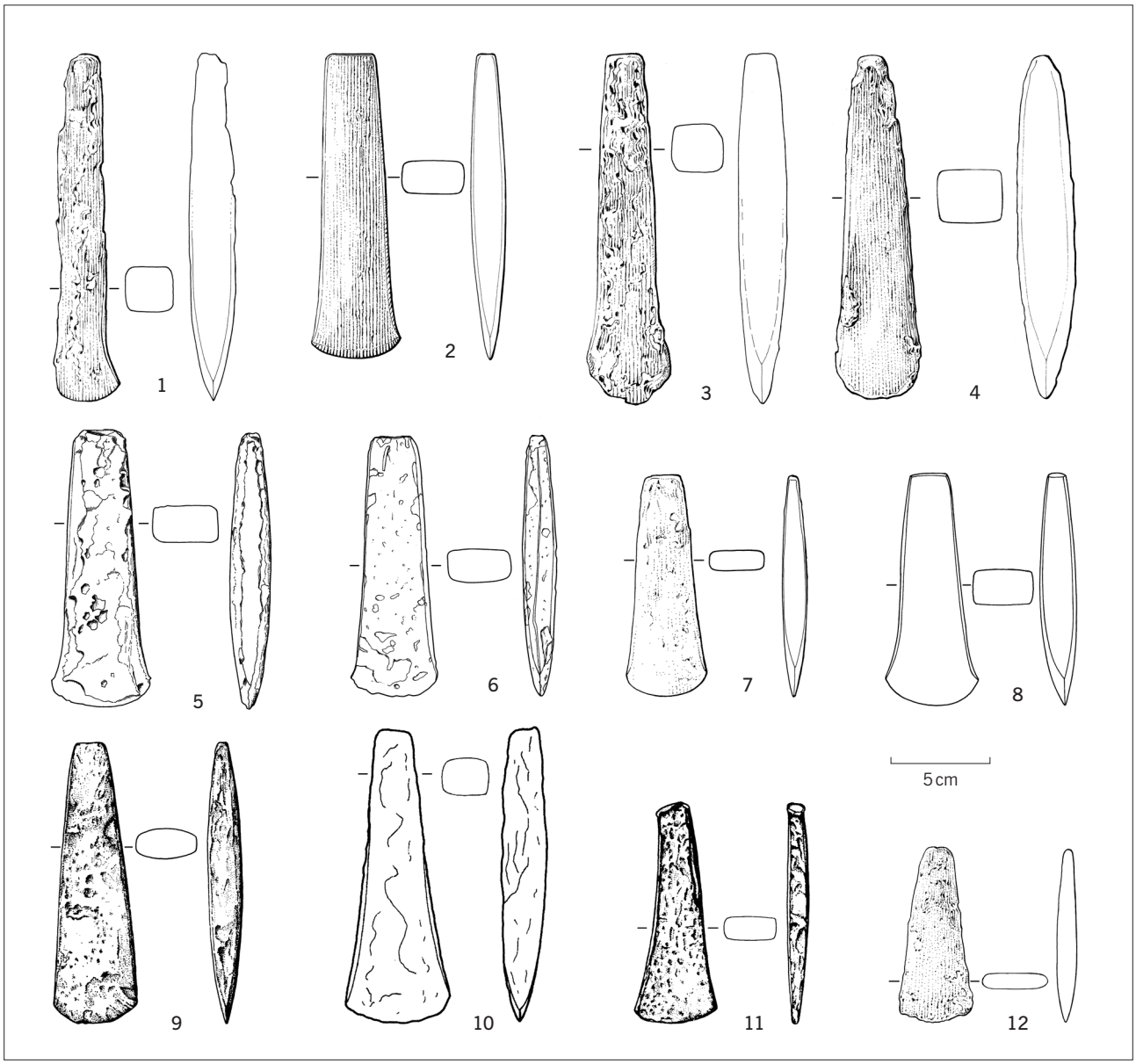

Abb. 6 Kupferne Flachbeile der ersten typologischen Gruppe (ca. 4400–3800 v. Chr.). Fundauswahl. In Klammern hinter der Fundstelle wird der Typ des Artefakts angegeben. 1 Halenkov, okr. Vsetín (Pločnik); 2 Vracov, okr. Hodonín (Stollhof); 3 Rymice, okr. Kroměříž (Jordanów); 4 Racková, okr. Zlín (Kaka/Treuen); 5 Dublovice, okr. Příbram (Strážnice); 6 Fojtovice, okr. Teplice (Strážnice); 7 Malhostovice, okr. Brno-venkov (Malhostovice); 8 Rohovládova Bělá, okr. Pardubice (Hartberg); 9 Komořany, okr. Most (Rödigen); 10 Osík, okr. Svitavy (Osík); 11 Praha-Liboc (Všetaty); 12 Luhačovice, okr. Zlín (Belsdorf?).

Fig. 6 *Copper flat axes of the first typological group (c. 4400–3800 BC). Selection. The type of artefact is given in parentheses after the site of discovery. 1 Halenkov, Vsetín district (Pločnik); 2 Vracov, Hodonín district (Stollhof); 3 Rymice, Kroměříž district (Jordanów); 4 Racková, Zlín district (Kaka/Treuen); 5 Dublovice, Příbram district (Strážnice); 6 Fojtovice, Teplice district (Strážnice); 7 Malhostovice, Brno-venkov district (Malhostovice); 8 Rohovládova Bělá, Pardubice district (Hartberg); 9 Komořany, Most district (Rödigen); 10 Osík, Svitavy district (Osík); 11 Praha-Liboc (Všetaty); 12 Luhačovice, Zlín district (Belsdorf?).*

len für ihre Herstellung traditionell im südlichen Teil der Karpaten gesucht (Patay 1984, 10; 55; 59; 87–88). Ob es sich bei den böhmischen und mährischen Funden um Importe von Fertigprodukten handelt oder ob sie aus importierten Halbfabrikaten vor Ort hergestellt wurden, lässt sich nach dem derzeitigen Kenntnisstand nicht entscheiden. Aufgrund der angenommenen technologischen Komplexität ihrer Herstellung ist jedoch die erstere Möglichkeit deutlich wahrscheinlicher (vgl. Kienlin/Pernicka 2009).

Eine sehr häufige Gruppe frühäneolithischer schwerer Kupfergegenstände umfasst Exemplare, die aus Antimonkupfer vom Typ Nógrádmarcal gegossen wurden (Schubert 1982). Typisch dafür ist ein Antimon- und Silbergehalt von einigen Zehntel Prozent, in Ausnahmefällen liegt er bei über 1 %; andere Spurenelemente sind höchstens im Bereich von wenigen Hundertstel Prozent vertreten. Die Gegenstände mit beschriebener Zusammensetzung konzentrieren sich am Nordrand des Karpatenbeckens westlich des Bükk-Gebirges (Patay 1984, 10; Novotná 1974, 7–10; 16–17 Tab.), mehr nach Westen in Mitteldeutschland und vereinzelt auch in Dänemark (Klassen u. a. 2011, 18 Tab. 1).

Von den ins Frühäneolithikum datierten Gegenständen wurde das Nógrádmarcal-Antimonkupfer bei ungefähr 50 Gegenständen aus Böhmen und Mähren identifiziert (siehe

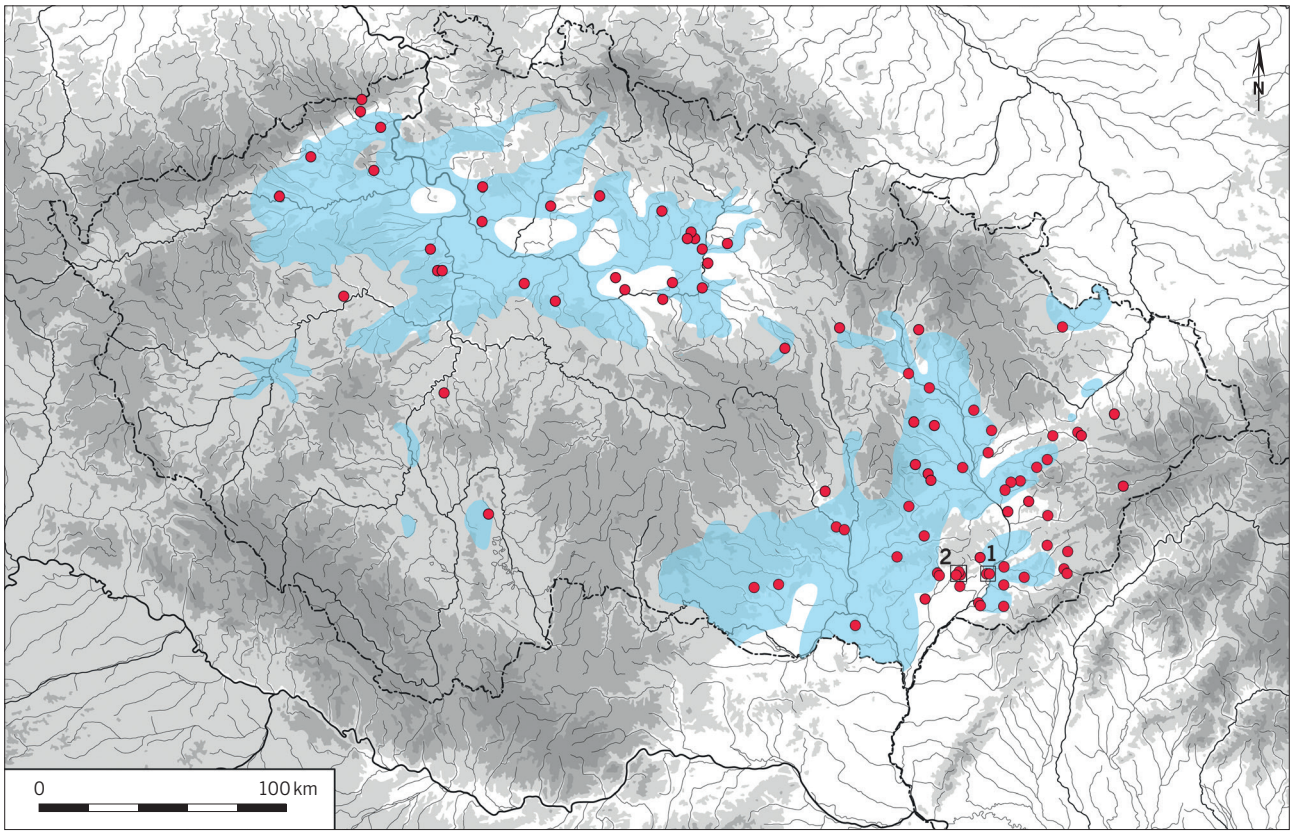

Abb. 7 Verbreitungskarte der kupfernen Flachbeile der ersten typologischen Gruppe in der Tschechischen Republik (ca. 4400–3800 v. Chr.). Hortfunde sind umrahmt. 1 Neda Konice, okr. Uherské Hradiště; 2 Vracov, okr. Hodonín. Für weitere Erläuterungen siehe Abb. 1.

Fig. 7 *Distribution map of the copper flat axes belonging to the first typological group in the Czech Republic (c. 4400–3800 BC). Hoards are circumscribed. 1 Neda Konice, Uherské Hradiště district; 2 Vracov, Hodonín district. For additional explanations, see Fig. 1.*

Dobeš 2013, Tab. 2; 4; 6; Dobeš u. a. 2015, Tab. 1; Dobeš u. a. 2019, Tab. 1–2). Dabei handelt es sich ausnahmslos um Kreuzäxte vom Typ Nógrádmarcal und um die meisten Flachbeile der oben erwähnten ersten typologischen Gruppe[10]. Nur vereinzelt wurde diese Materialgruppe bei Hammeräxten registriert: in Mähren gar nicht und in Böhmen etwa in zwei Fällen[11]. In das oben genannte Schema passt in dieser Hinsicht die Metallzusammensetzung zweier Kreuzäxte aus dem Hortfund von Roudnice hinein: Das Artefakt vom Typ Jászladány wurde aus Kupfer der Materialgruppe E00 und das Exemplar vom Typ Nógrádmarcal aus dem gleichnamigen Antimonkupfertyp hergestellt.

Die Streuung und Intensität des Vorkommens von Funden mit den beschriebenen Zusammensetzungen deuteten bereits in der Vergangenheit auf die Westkarpaten als mögliche Rohstoffquelle hin (Novotná 1982, 317). Für einen vorhandenen Bergbau bereits um 4000 v. Chr., also etwa zur Zeit der Herstellung von Kreuzäxten des Typs Nógrádmarcal, zeugen vor allem die Funde aus mittelalterlichen und modernen Bergbauhalden in Špania Dolina (dt. Herrengrund), okr. Banská Bystrica, im Slowakischen Erzgebirge. Bei ihrer sekundären Verarbeitung in der zweiten Hälfte des 20. Jhs. wurde eine große Anzahl prähistorischer Rillenhämmer zum Erzbrechen gefunden, zusammen mit Keramik der epilengyelzeitlichen Ludanice-Gruppe[12]. Die Ergebnisse der dortigen Bleiisotopenanalysen sind zwar nicht unproblematisch (Modarressi-Tehrani u. a. 2016, 121), aber die Zusammensetzung der Erze am besprochenen Fundort, hauptsächlich Chalkopyrit und Antimonfahlerze (Tetraedrit), schließt die Verbindung zum Nógrádmarcal-Kupfer nicht aus (Schreiner u. a. 2012, 362).

Die dritte frühäneolithische Materialgruppe stellt das Handlová-Kupfer dar. Aufgrund des Gehalts an Silber und Antimon ähnelt es dem Nógrádmarcal-Kupfer, unterscheidet sich jedoch durch das Vorkommen von Arsen, normalerweise in Zehntel Prozent. Die typologisch ausgeprägten gleichnamigen Hammeräxte sind bis auf zwei Ausnahmen nur im westlichen Teil der Slowakei belegt, sodass allein aus diesem Grund davon ausgegangen wird, dass der betreffende Rohstoff aus demselben geografischen Gebiet stammt (Schubert/Schubert 1999, 670–671; Tab. 1; Abb. 7). Auch die Befunde mit kupfernen Gussbarren und Tropfen, in denen Arsen und Antimon in Zehntel Prozent nachgewiesen wurden, könnten damit in Zusammenhang stehen[13].

10 Etwa 70 % in Böhmen und 60 % in Mähren, einschließlich aller Gegenstände aus dem Hortfund von Nedakonice, okr. Uherské Hradiště.

11 Exemplare der Typen Székely/Nádudvar aus Mlázovice, okr. Jičín, und Typ Szendrő aus Praha-Strahov.

12 Točík/Žebrák 1989; die neueste Übersicht findet sich bei Zachar/Salaš 2018, 47–49.

13 Dzeravá skala bei Plavecký Mikuláš, okr. Malacky (Slowakei): Farkaš 2013, 41–45 Abb. 12–13; Suchá nad Parnou, okr. Trnava (Slowakei): Novotný/Novák 1990, 136.

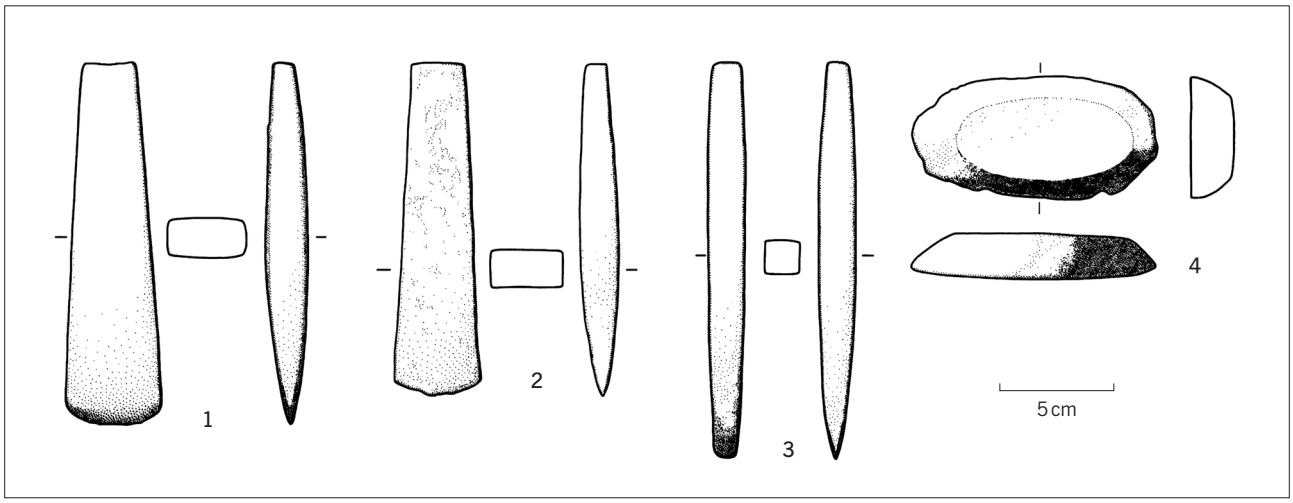

Abb. 8 Der Hortfund von Nedakonice, okr. Uherské Hradiště. 1–2 kupferne Flachbeile (Typ Stollhof); 3 Kupfermeißel; 4 Kupferbarren.

Fig. 8 *The hoard from Nedakonice, Uherské Hradiště district. 1–2 copper flat axes (type Stollhof); 3 copper chisel; 4 copper ingot.*

Ins Frühäneolithikum sind etwa zehn Funde aus dem Handlová-Kupfer zu datieren (siehe Dobeš 2013, Tab. 2; 6; Dobeš u. a. 2015, Taf. 1; Dobeš u. a. 2019, Tab. 1–2). Hervorzuheben ist das typologische Spektrum dieser Gegenstände: Von den Flachbeilen gehören dazu einerseits typologisch archaische Exemplare der Typen Pločnik und Stollhof, andererseits die fortgeschritteneren Typen bis Endtypen Strážnice, Belsdorf, Rödigen und Všetaty. Dem Anteil an Spurenelementen nach sind auch einige Hammeräxte vom Typ Kežmarok und sogar eine Kreuzaxt vom Typ Jászladány aus Hodonín, okr. Hodonín, hier zuzurechnen. Eine ähnliche Zusammensetzung besitzt auch die Hammeraxt vom Typ Szendrő aus Vepřek, okr. Mělník (Abb. 4,2), obwohl sie der Anteil von nur 0,02 % Silber und Antimon schon eher dem Mondsee-Kupfer nahebringt (siehe unten).

5. Altäneolithikum (ca. 3800–3400 v. Chr.)

Ein bedeutender Wendepunkt in der typologischen und materialtechnologischen Zusammensetzung von Kupferartefakten kam im ersten Viertel des 4. Jts. v. Chr., etwa mit dem Beginn der Trichterbecherkultur. Die Endtypen von Hammer- und Kreuzäxten liefen wahrscheinlich aus, während die Beile der zweiten typologischen Gruppe neu auftauchten (Dobeš 1989). Mit ihrer Form entfernen sich diese Beile bereits von den ursprünglichen steinernen Vorlagen und nutzen in größerem Maße die technischen Möglichkeiten des Metalls aus, ohne ihre Funktion zu beeinträchtigen; sie sind dünner und das Verhältnis zwischen ihrer Länge und Breite ist ausgewogener. Es handelt sich überwiegend um Flachbeile vom Typ Altheim (Beispiele siehe auf Abb. 9). Deren Vorkommen kann bereits an der Wende vom Früh- zum Altäneolithikum nachgewiesen werden[14]. Mit Sicherheit kommen sie noch im Mitteläneolithikum vor, ihre Verwendung bis ganz zum Ende des Äneolithikums ist jedoch nicht auszuschließen[15].

Die Flachbeile der zweiten typologischen Gruppe wurden überwiegend aus dem Mondsee-Kupfer gefertigt. Es zeichnet sich vor allem durch einen Gehalt an Arsen in Zehntel bis ganze Prozente und, im Gegensatz zum Handlová-Kupfer, durch die nahezu komplette Absenz von Antimon, Silber und anderen Spurenelementen aus, höchstens in Hundertstel Prozent und weniger. Der Ursprung des Rohstoffs für die Herstellung des Kupfers wurde lange in den Ostalpen gesucht, aber den neuen Bleiisotopenanalysen zufolge könnte es sich um nahezu reines Kupfer aus Südosteuropa (Serbien?) handeln, das in den Alpen mit Arsen nur angereichert wurde. Arsen könnte ihm in Form von Eisenarseniden, in der Terminologie des Hüttenwesens »Speise« genannt, zugesetzt worden sein. Auf die Nutzung dieser Technologie bereits im 4. Jt. v. Chr. weisen beispielsweise die Funde aus dem Iran und der Türkei hin (Pernicka/Frank 2015). Für einen bedeutenden technologischen Wendepunkt in der Herstellung von Kupfergegenständen zwischen dem Früh- und Altäneolithikum sprechen auch metallografische Analysen (Kienlin 2011, 131–142).

Auch hier handelt es sich meist um Einzelfunde (insgesamt fast 30 Exemplare), wobei die Horte von Laškov und Plumlov, beide okr. Prostějov, aus Flachbeilen des angegebenen Typs Altheim in Vergesellschaftung mit Dolchen vom Typ Mondsee bestehen (Šmíd 2009, 143–147 Abb. 2–4). Bisher wurden aus dem Untersuchungsgebiet 20 Beile vom Typ Altheim analysiert, wobei ca. 85 % aus dem Mondsee-Kupfer hergestellt wurden. In zwei Fällen konnte das Handlová-Kupfer identifiziert werden, was zusammen mit dem Hortfund von Malé Leváre (siehe oben) auf deren Herstellung bereits am Anfang des 4. Jts. v. Chr. hinweisen könnte. Das

14 Der Hortfund von Malé Leváre, okr. Malacky (Slowakei): Novotná 1970, 14; Taf. 48,B1; mehrere Beile des Typs Altheim wurden aus dem Handlová-Kupfer hergestellt, siehe unten.

15 Siehe hierzu ein Grab der Glockenbecherkultur in Santa Cristina di Fiesse, Prov. Brescia, in der Lombardei: Montelius 1900, 190 Abb. 469–470.

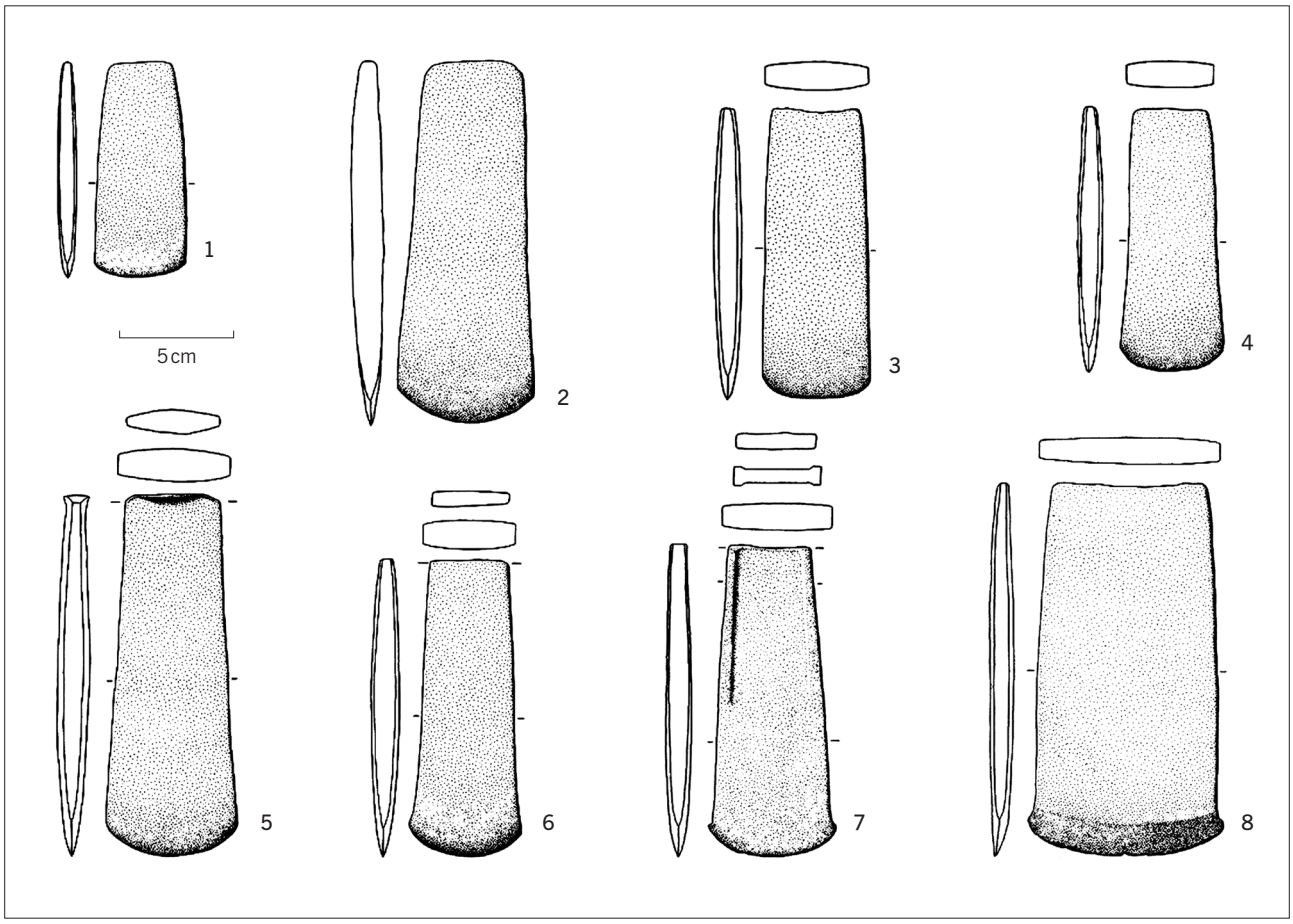

Abb. 9 Pratecký kopec, Katastergemeinde Prace, okr. Brno-venkov. Hortfund. 1 Flachbeil (Typ Zwerndorf); 2–5 Flachbeile (Typ Rudimov); 6–7 Flachbeile (Typ Altheim); 8 Flachbeil (Typ Vinča).

Fig. 9 *Pratecký kopec, cadastral district Prace, Brno-venkov district. Hoard. 1 flat axe (type Zwerndorf); 2–5 flat axes (type Rudimov); 6–7 flat axes (type Altheim); 8 flat axe (type Vinča).*

Flachbeil aus Františkovy Lázně, okr. Cheb, wurde anhand einer älteren Analyse (Otto/Witter 1952, Nr. 198) aus nahezu reinem Kupfer erzeugt (siehe Dobeš 2013, Tab. 7; Dobeš u. a. 2019, Tab. 1–2).

In diesem Horizont gibt es bereits mehrere Hinweise auf lokalen Kupferguss. Aus Mähren sei das Fragment eines Schmelztiegels aus Dyje, okr. Znojmo, oder eine Düse und ein Lehmbrocken mit Grünspan aus Podolí, okr. Brno-venkov, erwähnt, in beiden Fällen mit Spuren von Kupfer und Arsen, und zuletzt noch ein Gusstropfen aus Kostelec na Hané, okr. Prostějov (Rožnovský/Šmíd 2015, 38; 50; Abb. 5; Kos/Šmíd 2015, 61; 67; Abb. 3,8). In Böhmen ist bislang nur ein Schmelztiegelfragment aus der Kultstätte von Makotřasy, okr. Kladno, nachweisbar (Dobeš 2013, 100; Taf. 21).

6. Mitteläneolithikum (ca. 3400–2800 v. Chr.)

Das typologische Spektrum von Flachbeilen der zweiten Gruppe erweiterte sich nachweisbar erst im Mitteläneolithikum. Kulturgeschichtlich handelt es sich bei dem Untersuchungsgebiet um die Periode der Badener Kultur und der daraus hervorgegangenen Postbadener Kulturen. Zusätzlich zu den noch vorkommenden Beilen vom Typ Altheim begegnen wir, anhand der stratifizierten Befunde und der Kombination verschiedener Typen in Horten, wahrscheinlich zum ersten Mal den Beiltypen Vinča, Rudimov, Pölshals und Zwerndorf[16]. Von Bedeutung ist hierbei der verschleppte Hort von Pratecký kopec (dt. Pratzeberg), okr. Brno-venkov, der aus acht bis neun Flachbeilen fast aller oben genannten Typen besteht (vgl. Abb. 9–10).

Am Ende des Mitteläneolithikums tauchen auch in der Tschechischen Republik als völlig fremdes Element die Schafthalsäxte auf. Ihre ältesten Formen sind bereits am Ende des 5. Jts. v. Chr. im Iran belegt, von wo aus sie sich weiter ausbreiteten. Der mit ihrer Herstellung verbundene Wissenstransfer, vermittelt durch die Träger der Jamnaja-Kultur, gelangte höchstwahrscheinlich vom Kaukasus nach Mittel- und Südosteuropa etwa um 3000 v. Chr. (Bátora 2003). Einer der entscheidenden Befunde für die Bestimmung des Beginns ihres Eindringens in Europa bleibt der Hortfund von Brno-Líšeň, der aufgrund der stratigrafischen Lage sehr wahr-

16 Zusammenfassend mit weiterer Literatur Dobeš 2013, 41; 130.

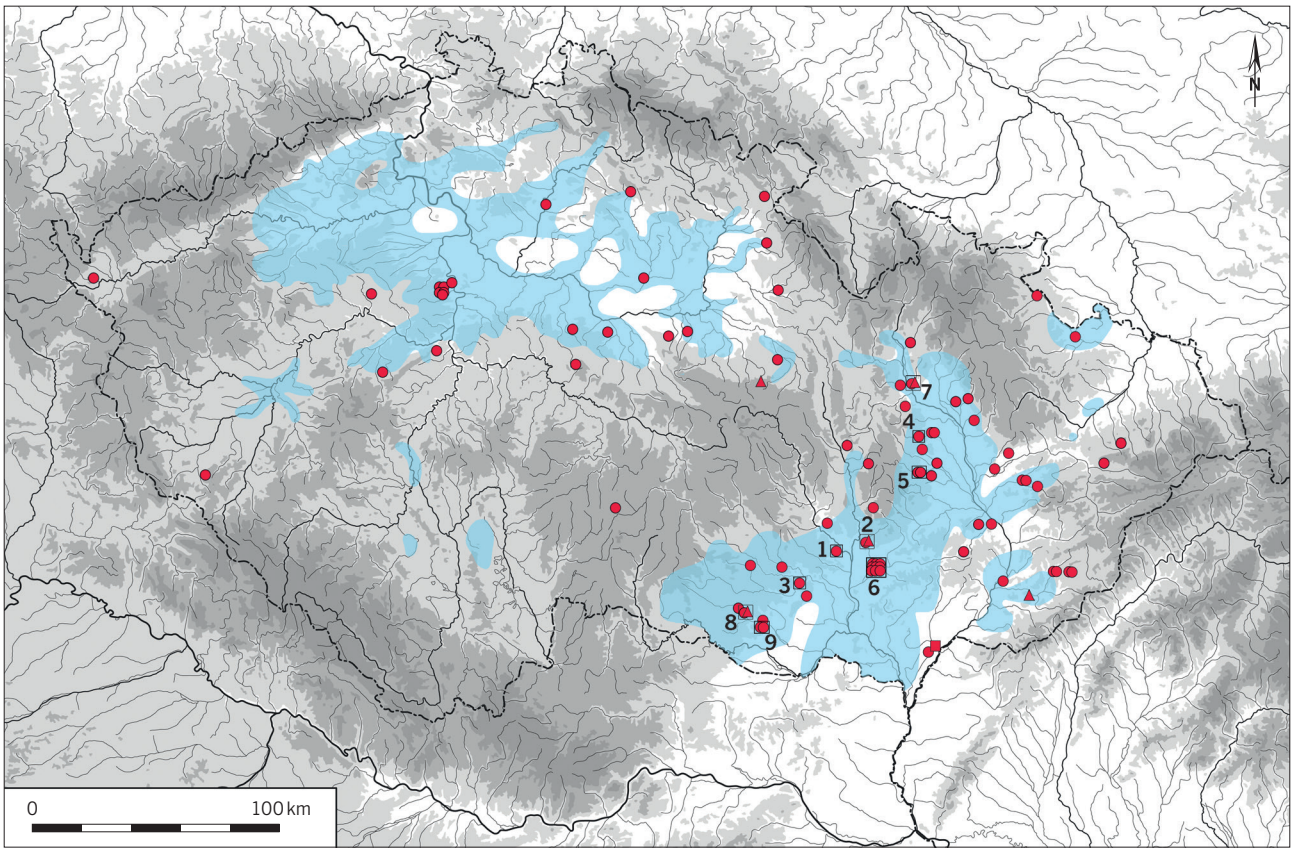

Abb. 10 Verbreitungskarte der Flachbeile der zweiten und dritten typologischen Gruppe, der Schafthalsäxte und der Hammeraxt vom Typ Eschollbrücken in der Tschechischen Republik (ca. 3800–2200 v. Chr.; Details zur Datierung einzelner Fundkategorien/-typen finden sich im Text). Die Kreise deuten auf Flachbeile, die Dreiecke auf Schafthalsäxte und das Quadrat auf die Position der Hammeraxt vom Typ Eschollbrücken aus Lužice, okr. Hodonín, hin. Hortfunde sind umrahmt: 1 Brno-Bosonohy; 2 Brno-Líšeň; 3 Budkovice, okr. Brno-venkov; 4 Laškov, okr. Prostějov; 5 Plumlov, okr. Prostějov; 6 Prace, okr. Brno-venkov; 7 Stavenice, okr. Šumperk; 8 Tvořihráz, okr. Znojmo; 9 Vevčice, okr. Znojmo. Für weitere Erläuterungen siehe Abb. 1.

Fig. 10 *Distribution map of the flat axes belonging to the second and third typological group, of the shaft-hole axes, and of the axe-hammer (type Eschollbrücken) in the Czech Republic (c. 3800–2200 BC; details on dating the find categories/types are in the text). Circles denote the flat axes, triangles the shaft-hole axes, and the square the site at Lužice, Hodonín district – the find location of the axe-hammer (type Eschollbrücken). Hoards are circumscribed: 1 Brno-Bosonohy; 2 Brno-Líšeň; 3 Budkovice, dist. Brno-venkov; 4 Laškov, Prostějov district; 5 Plumlov, Prostějov district; 6 Prace, Brno-venkov district; 7 Stavenice, Šumperk district; 8 Tvořihráz, Znojmo district; 9 Vevčice, Znojmo district. For additional explanations, see Fig. 1.*

scheinlich mit der dortigen Ansiedlung der Jevišovicer Kultur zusammenhängt (Benešová 1956). Die typologisch archaischen Schafthalsäxte (Fajsz, Corbasca) in Mähren sind Bestandteile anderer Horte (Abb. 11)[17], wo sie in Vergesellschaftung mit lokalen Typen der kupfernen Flachbeile (Zwerndorf, Rudimov) vorkommen und damit unter anderem ihre Datierung ins Mitteläneolithikum bestätigen.

Aus dem Mitteläneolithikum wurden 31 der 47 erfassten Flachbeile und zwei der fünf erfassten Schafthalsäxte analysiert (ohne Einbeziehung der Exemplare des Typs Altheim). Das resultierende Bild ist relativ bunt und spiegelt wahrscheinlich die Herkunft von Kupfer aus mehreren Quellen, beziehungsweise die Anwendung verschiedener technologischer Verfahren wider[18]. Es überwiegt weiterhin das Mondsee-Kupfer (ca. 75 % aller Analysen), das bei einer Schafthalsaxt (Stavenice), allen Flachbeilen vom Typ Vinča und den meisten Flachbeilen vom Typ Rudimov nachgewiesen wurde. Antimonkupfer (etwa Zehntel Prozent Sb) tritt neu auf, im Vergleich zum Nógrádmarcal-Kupfer ohne deutlicheren Silbergehalt (nur Hundertstel Prozent Ag). Daraus wurden eine Schafthalsaxt aus dem Hortfund von Brno-Líšeň und zwei Exemplare von Flachbeilen des Typs Rudimov hergestellt. In fünf Fällen ist für die Typen Pölshals und Zwerndorf Kupfer nachgewiesen, das ungefähr der Materialgruppe E00 entspricht. Bei einem der Beile vom Typ Rudimov aus Praha-Libeň wurde das Handlová-Kupfer identifiziert[19].

Aus dem Mondsee-Kupfer wurden im Mitteläneolithikum (und wahrscheinlich auch im Frühäneolithikum) nicht nur schwere Kupfergegenstände hergestellt, sondern auch Schmuck, z. B. alle analysierten Objekte aus dem bisher reichsten äneolithischen Grab in Velvary, okr. Kladno, darunter ein einzigartiges halbmondförmiges Pektorale (Pleslová-Štiková 1992; Dobeš 2013, 59 Abb. 4; 110 Tab. 10; Taf. 14,1).

17 Vevčice, okr. Znojmo: Říhovský 1992, 37; Taf. 5,35; 11,116; Stavenice, okr. Šumperk: Dobeš u. a. 2019, 21 Abb. 11,3–4.

18 Beispielsweise bei Artefakten ohne Arsen kommen die Verfahren infrage, die keine absichtliche Zugabe von Eisenarseniden beinhalten.

19 Dobeš 2013, Tab. 7; Smejtek 2015, 183; Dobeš/Fikrle 2017, 127 Tab. 1; Dobeš u. a. 2019, Tab. 1–2.

Abb. 11 Stavenice, okr. Šumperk, Hortfund. 1 Schafthalsaxt (Typ Corbasca); 2 Flachbeil (Typ Rudimov).

Fig. 11 *Stavenice, Šumperk district, hoard. 1 shaft-hole axe (type Corbasca); 2 flat axe (type Rudimov).*

7. Jungäneolithikum (2800–2200 v. Chr.)

Die Menge und Variabilität von metallenen Äxten und Beilen im Kontext der Becherkulturen sind aus Sicht der verfügbaren Quellen recht vernachlässigbar. Es bleibt natürlich die Frage, inwieweit unsere Quellen die vergangene Realität erfassen (Fischer 1973, 226; Heyd 2004, 188–197).

In diesem Zusammenhang müssen wir noch das einzigartige Exemplar einer Hammeraxt vom Typ Eschollbrücken aus Lužice in Mähren erwähnen (Abb. 12,1), das wie andere Exemplare dieses Typs in seiner Form den facettierten Hammeräxten der schnurkeramischen Kultur und dem dekorativen Fischgrätenmuster auf ihren Bechern ähnelt. Diese Hammeraxt gehört zu einer Gruppe von etwa zehn ähnlichen Exemplaren, die hauptsächlich im Rhein- und Weserbecken gefunden wurden (Kibbert 1980, 23–35; Taf. 1; 60), mit einer Analogie im Theißgebiet (Kalicz 1998, 174 Abb. 13,6; Dani/Kulcsár 2021, 336–337 Fig. 6), welche die oben angeführte Datierung voll und ganz bestätigt. Auf das Gebiet und die fortschrittliche Methode ihrer Herstellung weisen Fragmente einer zweiteiligen Gussform vom Rainberg in Salzburg hin (Hell 1943, 58 Abb. 1,2). Spektralanalysen des Materials der jeweiligen Exemplare deuten auf die Verwendung von Kupfer, das nicht mit Arsen legiert war. Im Fall der Hammeraxt aus Lužice ähnelt die Zusammensetzung des Metalls stark dem Nógrádmarcal-Kupfer (Dobeš u. a. 2019, Tab. 2; siehe auch Kibbert 1980, 290).

Der symbolische Gehalt der beschriebenen Artefakte war sicherlich beträchtlich, ihr Vorkommen ergibt erst einen Sinn »im Kontext der Vorstellungswelt der Träger der schnurkeramischen Kultur, die diesen Objekten eine so große Wertschätzung entgegenbrachten, dass sie ausschließlich übernatürlichen Mächten geweiht wurden« (Maran 2008, 180).

In zweiteiligen Gussformen könnten auch die Beile der dritten typologischen Gruppe gegossen worden sein, die sich durch einen sechseckigen Querschnitt auszeichnen und somit auf eine ähnliche Herstellungsweise hindeuten. Ihr Vorkommen ganz am Ende des Äneolithikums wird neben der Gusstechnik auch durch den Hortfund von Budkovice, okr. Brno-venkov, bestätigt (Abb. 12,2), der aus einem Flachbeil und einer Rollenkopfnadel bestand (Ondráček 1961, 150 Abb. 3). Anhand der Nadel lässt sich der Befund zuverlässig in die Glockenbecherkultur datieren. Der dritten typologischen Gruppe von Flachbeilen lassen sich nur drei Exemplare aus der Tschechischen Republik zuordnen, von denen eines analysiert wurde (Praha-Dejvice, Typ Bytyń, Mondsee-Kupfer: Dobeš 2013, 31; 34; Taf. 10,1–2; 109 Tab. 7).

8. Schlussfolgerungen

Als die Menschen im Nahen Osten vor etwa 10 000 Jahren begannen, gediegenes Kupfer zur Herstellung von Schmuck zu verwenden, hatten sie sicherlich keine Ahnung, welche technologischen Möglichkeiten in diesem Material verborgen waren. Genauso wie Artefakte aus anderen beeindruckenden Materialien, diente es hauptsächlich zur Herstellung von Objekten mit symbolischem Charakter, Prestigegütern, Weihgaben usw. So wurden in Europa in den Jahrhunderten um die Wende vom 5. zum 4. Jt. v. Chr. Artefakte mit ähnlicher Funktion, aber aus unterschiedlichen Materialien nebeneinander gefunden, seien es neben schweren Kupfergegenständen die Jadeitbeile im Westen oder die Steinzepter in den nordpontischen Steppen (Pétrequin u. a. 2010; Govedarica 2004). Allerdings blieb Stein auch im Äneolithikum das Hauptmaterial für die Herstellung von Werkzeugen. Es mussten noch mehrere tausend Jahre vergehen bis auch Werkzeuge massenhaft aus Metall hergestellt wurden. Metallartefakte lösten sich vollständig von ihren ursprünglichen steinernen Vorlagen und nahmen neue Formen an, wobei sie aufgrund ihrer Gebrauchseigenschaften den Stein aus vielen Bereichen des menschlichen Lebens vollständig verdrängten. Aber das ist schon eine andere Geschichte,

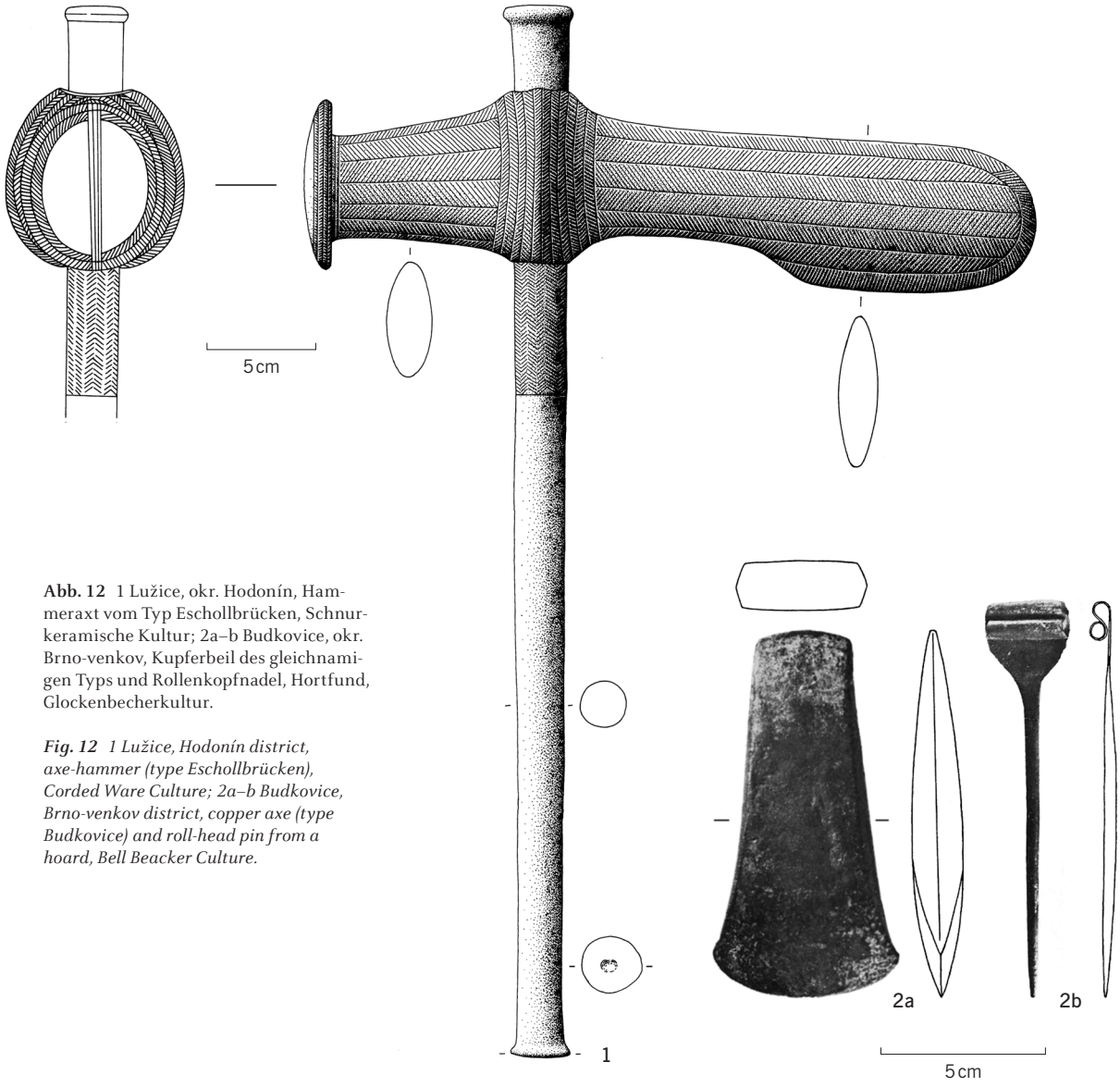

Abb. 12 1 Lužice, okr. Hodonín, Hammeraxt vom Typ Eschollbrücken, Schnurkeramische Kultur; 2a–b Budkovice, okr. Brno-venkov, Kupferbeil des gleichnamigen Typs und Rollenkopfnadel, Hortfund, Glockenbecherkultur.

Fig. 12 *1 Lužice, Hodonín district, axe-hammer (type Eschollbrücken), Corded Ware Culture; 2a–b Budkovice, Brno-venkov district, copper axe (type Budkovice) and roll-head pin from a hoard, Bell Beacker Culture.*

die Geschichte der Bronzezeit und der darauffolgenden Epochen. Sicher ist jedoch, dass ohne die Entdeckung der Technik des Kupfergusses im Chalkolithikum/Äneolithikum, die für die Herstellung damals »unpraktischer« Gegenstände bestimmt war, die Entwicklung in der Alten Welt vermutlich völlig anders verlaufen wäre.

Deutsch von Jana Kličová

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Anschrift

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The lifecycle of early metal axes from Italy, c. 4300–2200 BC

Andrea Dolfini

Zusammenfassung

Der Lebenszyklus früher Metallbeile aus Italien, ca. 4300–2200 v. Chr.

Anhand der neuesten Forschungsprojekte beschäftigt sich dieser Beitrag mit dem Lebenszyklus von Beilen aus Kupferlegierung im Neolithikum und in der Kupferzeit Italiens, ca. 4300–2200 v. Chr. Nach der Untersuchung der Erzmineralquellen, die frühen Schürfern und Bergleuten zur Verfügung standen, wird hier eine neue Chronologie vorgestellt, welche die meisten italienischen Beiltypen erstmalig fünf gutdatierten Horizonten zuweist. Schließlich werden Beilherstellung, einschließlich gewählter Legierungs-, Guss- und Schmiedeverfahren thematisiert. Sodann folgt eine Synthese der Forschung zur Verwendung von Beilen anhand von umfangreichen Daten aus Gebrauchsspurenanalysen und der Experimentalarchäologie. Zusätzlich sollen Umlauf und Tausch der Beile durch Bleiisotopenanalysen untersucht sowie Niederlegungspraktiken durch eine Neuaufnahme des archäologischen Befunds geprüft werden. Abschließend präsentiert dieser Beitrag neue Erkenntnisse über den sozialen Wert früher italienischer Beile in ihrem dynamischen Lebenszyklus mit seinen vielschichtigen Phasen von Herstellung, Gebrauch, Umgestaltung, Weitergabe und Niederlegung im Rahmen sozial bedeutsamer Ereignisse und Praktiken.

Schlagwörter Italien, Spätneolithikum, Kupferzeit, Metallurgie, Beile

Summary

This paper explores the lifecycle of copper-alloy axes in Neolithic and Copper Age Italy, c. 4300–2200 BC, drawing on the findings of recent research projects. Beginning with an investigation of the ore-mineral resources available to early prospectors and miners, the paper introduces a novel chronology that, for the first time, assigns most types of Italian axes to five well-dated horizons. The study further delves into axe production, encompassing alloying, casting, and forging choices. A synthesis of research of axe use is then conducted, drawing on extensive traceological data and replicative experiments. Additionally, the circulation and exchange of axes are explored through lead isotope analysis, and deposition practices are scrutinised through a fresh re-examination of the archaeological record. In conclusion, the paper offers new insights into the social value of early Italian axes as they navigated a dynamic life cycle involving complex episodes of manufacture, use, refashioning, handover, inheritance, and deposition as part of socially significant events and practices.

Keywords Italy, Late Neolithic, Copper Age, metallurgy, axes

Introduction

This paper explores the lifecycle of Neolithic and Copper Age metal axes from Italy, c. 4300–2200 BC. The data and interpretations examined in the following pages have been enabled by two decades of sustained interdisciplinary research into the origins of metallurgy south of the Alps. The paper provides a critical synthesis of this research, focusing on copper-alloy axes and the social context of their production and consumption. The first section reviews southern Alpine and peninsular ore sources and their prehistoric mining, processing, and smelting. The second section discusses the chronology of early Italian axes based on targeted research coordinated by this author (Iaia/Dolfini 2021). The third section examines alloying, casting, and forging choices in axe production. The fourth section discusses axe exchange as revealed by lead isotope analysis. The fifth section investigates how metal axes were used in prehistoric Italy, based on extensive microwear data. Finally, the sixth section explores the deposition of axes and other metal objects in burials. Critical remarks on the social value of early Italian axes conclude the paper.

Ore sources and their prehistoric exploitation

The Italian Peninsula encompasses two main ore-mineral districts in the south-eastern Alps (Trentino and Alto Adige/South Tyrol administrative regions, and parts of Veneto) and west-central Italy, especially in the *Colline Metallifere* (Ore Mountains) of western Tuscany (Fig. 1). Noteworthy, if scattered, ore deposits are situated in the Western and south-western Alps straddling the French-Italian border. Minor deposits and outcrops also lie in the central Alps, the northern Apennines, an area comprising southern Tuscany and northern Lazio, and – after a significant gap starting north of Rome and ending south of Naples – the mountains of Calabria in the ›toe‹ of Italy. No ore deposits

Fig. 1 Map of the sites, regions, and geographic features mentioned in the paper. 1 Libiola; 2 Monte Loreto; 3 Grotta della Monaca; 4 Saint Véran; 5 Roua; 6 San Carlo-Cava Solvay; 7 Orti Bottagone; 8 Trento; 9 Boschetti di Chiozza; 10 Sgurgola-Casali; 11 Col del Buson; 12 Pigloner Kopf; 13 Remedello; 14 The Iceman; 15 Arene Candide; 16 Zug-Riedmatt; 17 Ponte San Pietro; 18 Terni; 19 Rapolano; 20 Casetta Mistici; 21 Gaudello; 22 Celletta dei Passeri. Hollow circles: modern cities.

Abb. 1 *Karte der im Text erwähnten Fundorte, Regionen und naturräumlichen Einheiten. 1 Libiola; 2 Monte Loreto; 3 Grotta della Monaca; 4 Saint Véran; 5 Roua; 6 San Carlo-Cava Solvay; 7 Orti Bottagone; 8 Trento (dt. Trient); 9 Boschetti di Chiozza; 10 Sgurgola-Casali; 11 Col del Buson; 12 Pigloner Kopf; 13 Remedello; 14 Ötzi; 15 Arene Candide; 16 Zug-Riedmatt; 17 Ponte San Pietro; 18 Terni; 19 Rapolano; 20 Casetta Mistici; 21 Gaudello; 22 Celletta dei Passeri. Leere Kreise: moderne Städte.*

exist east of the Apennines due to the different geology of this region.

Italian ore bodies exhibit high variability, ranging from primary copper and iron-copper sulphides (especially abundant in the Alps and Tuscany) to polymetallic sulphides and sulphosalts that may be naturally rich in arsenic and antimony as well as copper. Secondary copper ores are relatively common in peninsular Italy, but less common in the Alps. Galena (lead sulphide, occasionally argentiferous) is found throughout the region, while localised sources of stibnite (antimony sulphide) are present in southern Tuscany and were apparently exploited in the 4th millennium BC as a source of metallic antimony. Tin-bearing cassiterite exists in the Tuscan Ore Mountains, but its prehistoric extraction is debated. Significant iron and zinc deposits are also found in the southern Alps and west-central Italy, although they were not systematically mined until the 1st millennium BC (see Dolfini 2013; Dolfini 2014 for references).

Evidence of prehistoric ore extraction is scarce due to the impact of historic mining in all main Italian deposits. However, notable exceptions are known in Calabria, Liguria (north-western Apennines), and the Western Alps. In Calabria, brightly coloured (secondary) copper and iron minerals were sourced at Grotta della Monaca from the 5th to the 2nd millennia BC (Fig. 2). It is unclear whether these minerals were smelted to extract metallic copper or simply crushed and transformed into pigments (Caricola et al. 2020; Larocca 2005). The earliest evidence of ore

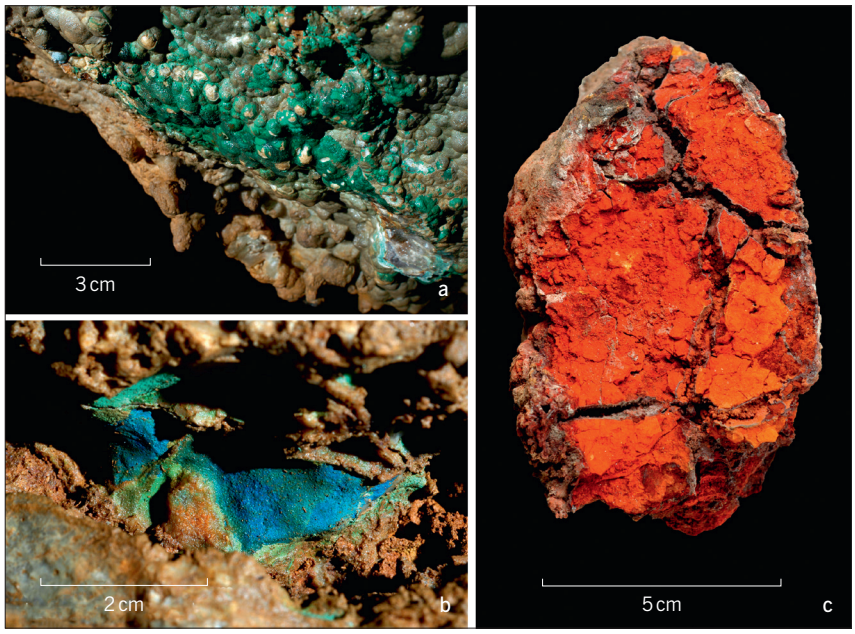


Fig. 2a–c Secondary ore-mineral compounds from Grotta della Monaca, Calabria, southern Italy. a Malachite concretions on limestone; b associated malachite and azurite; c hematite block.

Abb. 2a–c *Sekundäre Erzminerale aus der Grotta della Monaca, Kampanien, Süditalien. a Malachitkonkretion auf Kalkstein; b Malachit vergesellschaftet mit Azurit; c Hämatitblock.*

mining for likely high-temperature reduction comes from Libiola and Monte Loreto, Liguria. Here, underground veins of chalcopyrite (iron-copper sulphide) were loosened through fire-setting and then dug up using grooved hammerstones. The ore was subsequently crushed and sorted a short distance away from the mine shafts, although there is no evidence of ore smelting near the sites. Libiola and Monte Loreto were mainly worked in two discrete periods: the mid-4th and early/mid-3rd millennia BC (Maggi/Pearce 2005; Pearce 2007, 62–70). In the Western Alps, bornite (iron-copper sulphide) was mined and smelted from the late 3rd millennium BC at Saint Véran, Hautes-Alpes department, France, a high-altitude site that could only be frequented in the summer (Bourgarit et al. 2008; Bourgarit et al. 2010). Further evidence of early copper mining has also come to light in the Western and south-western Alps, including native-copper mines at Roua, Alpes-Maritimes department, France (Bussone 2023; O'Brien 2015, 121).

Evidence of copper smelting has been unearthed at San Carlo-Cava Solvay, Tuscany (hereafter San Carlo), a now-destroyed domestic site in the Tuscan Ore Mountains. Here, abundant remains of processed ore, slag, and crucibles were brought to light near open-air hearths that might be interpreted as roasting platforms (Fig. 3). Scientific analysis shows that copper and iron-copper sulphides and sulphosalts were smelted at this site using an efficient reduction technology that allowed the near-complete separation of the slag from the molten matte. San Carlo is radiocarbon-dated to the late 4th millennium BC, a time when copper production and consumption boomed in west-central Italy (Artioli et al. 2016; Fedeli/Galiberti 2016). Interestingly, ongoing research at Orti Bottagone, a nearby open-air site, suggests that copper and iron-copper sulphides might first have been reduced in Tuscany in the Final Neolithic (c. 4000–3650 BC). This chronology is based on diagnostic pottery associated with the copper slag and awaits confirmation by radiocarbon dating (Armigliato 2024).

Several copper-smelting sites dating to the mid/late 3rd millennium BC have been excavated in the south-eastern Alps (Artioli et al. 2015; Pearce 2007; Pearce et al. 2022). Western Alpine Saint Véran also dates to this period (see above). This highlights that the knowledge of how to smelt copper and iron-copper sulphides and sulphosalts, which had been perfected in Tuscany since the 4th millennium BC, was harnessed for the high-temperature processing of Alpine copper ores from about 2500 BC onwards. This laid the groundwork for the boom in copper extraction witnessed in the south-eastern Alps in the 2nd millennium BC[1].

Chronology

For most of the 20th century, scholars of late prehistoric Italy made a concerted effort to classify axes and other metal objects in order to build a chronology for the Copper and Bronze Ages, following the typological method pioneered by O. Montelius (1903), P. Reinecke (1965), and others. R. Peroni (1971; Peroni 1996) first proposed a detailed chronology for early Italian metalwork grounded in the typological method. He assigned several diagnostic axes, daggers, and halberds to two phases: either the Late Copper Age (mid/late 3rd millennium BC) or the initial Early Bronze Age, phase 1 (c. 2200–2000 BC). V. Bianco Peroni (1994) and G. L. Carancini (1993; Carancini 2001; Carancini 2023) further developed Peroni's chronology, while de Marinis (2006; de Marinis 2013) proposed a slightly different classification for northern Italian metals and backdated their earliest use to 3000/2800 BC.

1 Addis et al. 2016; Addis et al. 2017; Artioli et al. 2013; 2020; Ling et al. 2019; Nørgaard et al. 2021.

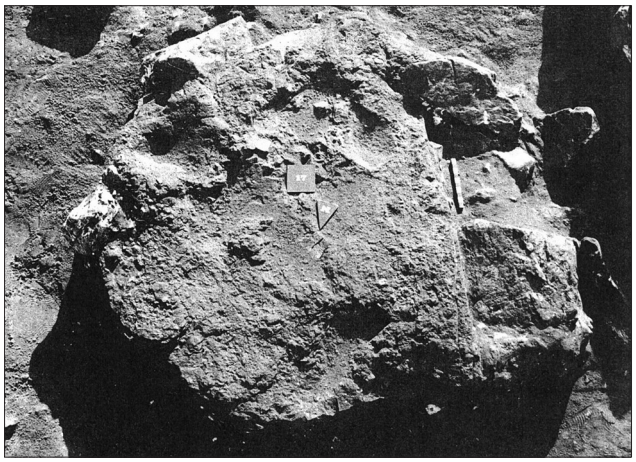


Fig. 3 San Carlo-Cava Solvay, Tuscany. Late 4th millennium BC fired-clay hearth possibly used as a roasting platform for the processing of copper and iron-copper sulphides and sulphosalts. The scale bar on the right is 10 cm long.

Abb. 3 *Cava Solvay, San Carlo, Toskana. Feuerstelle des späten 4. Jts. v. Chr. aus gebranntem Ton, möglicherweise als Röstplattform bei der Verarbeitung von Kupfer- und Eisen-Kupfer-Sulfiden und -Sulfosalzen verwendet.*

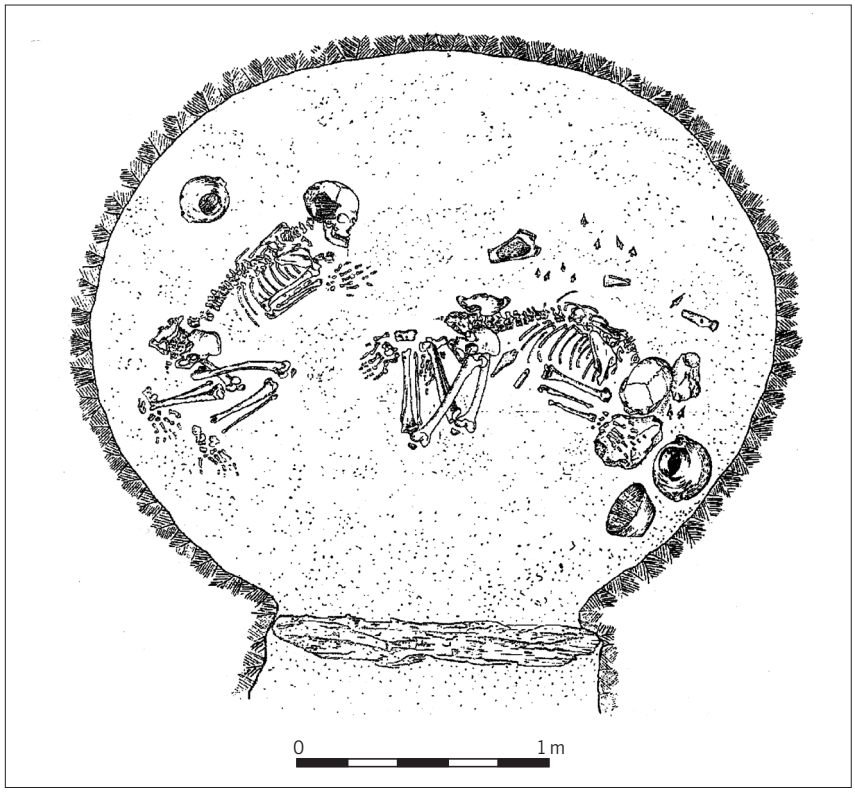


Fig. 4 Ponte San Pietro, Lazio, tomb 20. The two individuals laid to rest in this Rinaldone-style chamber tomb – a male and a female – were accompanied by gender-defining grave goods including a copper-alloy axe and a dagger (placed beside the male burial on the right). Both burials are radiocarbon-dated to the mid-4th millennium BC.

Abb. 4 *Ponte San Pietro, Latium, Grab 20. Den beiden in diesem Kammergrab im Stil der Rinaldone-Kultur bestatteten Individuen – eines männlich, eines weiblich – waren geschlechtsspezifische Grabbeigaben mitgegeben worden, einschließlich eines Beils aus einer Kupferlegierung und eines Dolches (neben der männlichen Bestattung rechts). Beide Bestattungen wurden auf die Mitte des 4. Jts. v. Chr. radiokarbondatiert.*

Problems with these chronologies began to surface in the 1990s when Accelerator Mass Spectrometry (AMS) radiocarbon dating was first systematically performed on Copper Age burials and associated metals. The new dates showed that copper-alloy axes, daggers, and halberds were initially placed at Rinaldone-style funerary sites, west-central Italy, in the mid-4th millennium BC (Fig. 4) – hundreds of years earlier than previously thought. The radiocarbon dates also revealed that metals were placed in Remedello-style and Gaudo-style burials (northern and south-western Italy, respectively) from the late 4th millennium BC – again, earlier than most scholars had previously surmised[2].

To resolve the controversy thrown open by radiocarbon dating, C. Iaia and A. Dolfini reassessed the chronology and tempo of the adoption of metallurgy in Italy (Iaia/Dolfini 2021). Their four-pronged approach to the problem involved (a) the reclassification, enhanced by morphometric analysis, of a large sample of early Italian axes (and also daggers and halberds, not discussed here); (b) the re-examination of diagnostic metal and non-metal objects from (mostly) single-phase burials; (c) the establishment of typological crosslinks with well-dated metals from Central Europe; and (d) the assessment of radiocarbon dates from metal-rich burials, supplemented by fresh AMS dates and Bayesian statistics. Thanks to this research approach, they were able to subdivide early Italian metalwork into five discrete horizons, from the Late/Final Neolithic to the Final Copper Age (Fig. 5). These horizons are presented below.

Horizon 1: Late and Final Neolithic (4500–3650 BC)

Copper-alloy objects – mainly awls, pins, and wire rings – first circulated south of the Alps in this period, from

2 Carboni 2020; Cocchi Genick 2013; Conti et al. 1997; Dolfini 2010; Miari et al. 2017; Passariello et al. 2010.

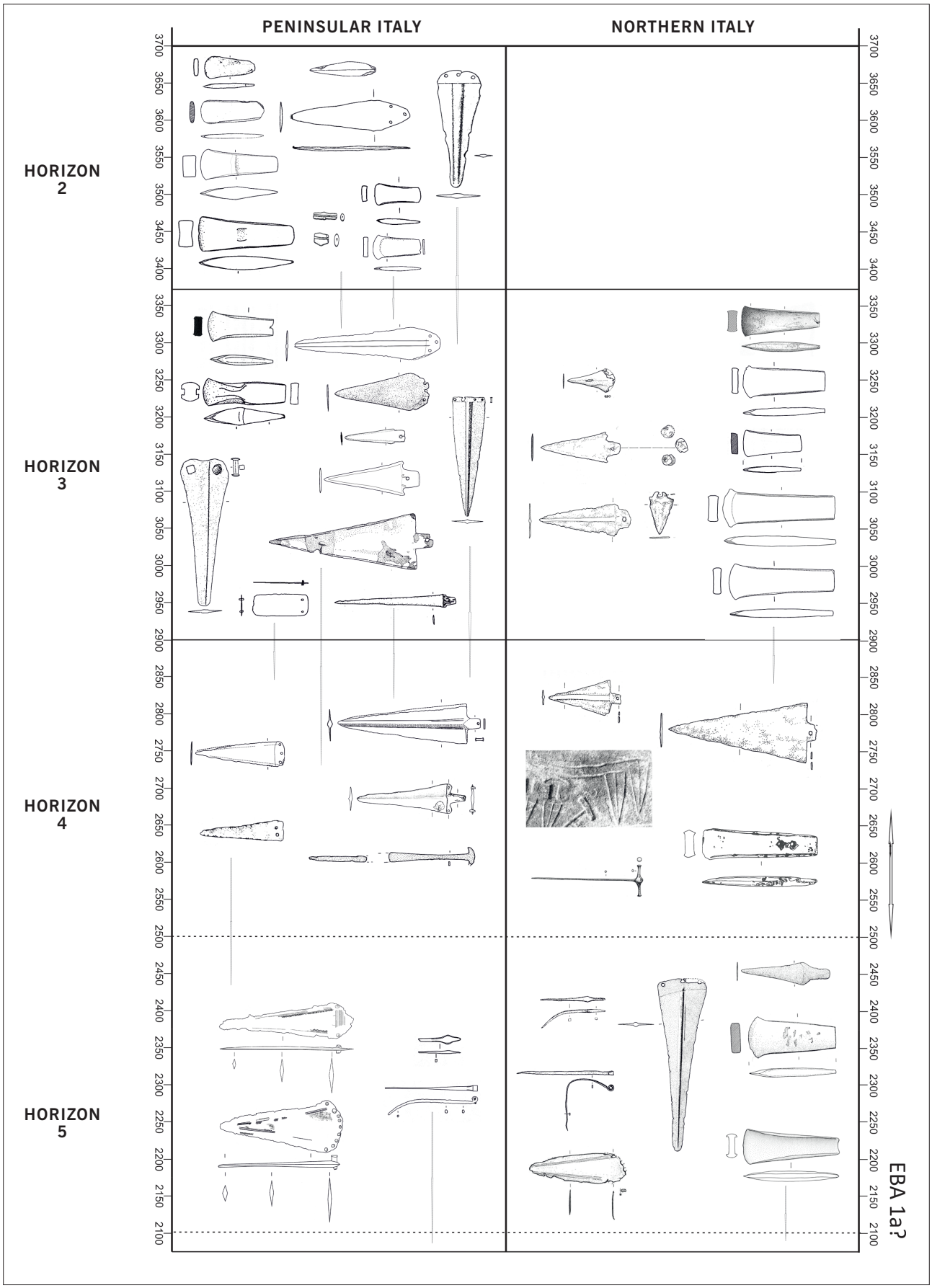


Fig. 5 Synopsis of the principal types of metal artefacts defining Horizons 2–5 in northern and peninsular Italy (see Fig. 6 for Horizon 1). The artefacts are not to scale (cf. Iaia/Dolfini 2021).

Abb. 5 *Zusammenfassung der wichtigsten Typen von Metallartefakten, welche die Horizonte 2–5 in Oberitalien und auf der Apenninalbinsel definieren (s. Abb. 6 für Horizont 1). Die Artefakte sind nicht maßstabsgetreu (vgl. Iaia/Dolfini 2021).*

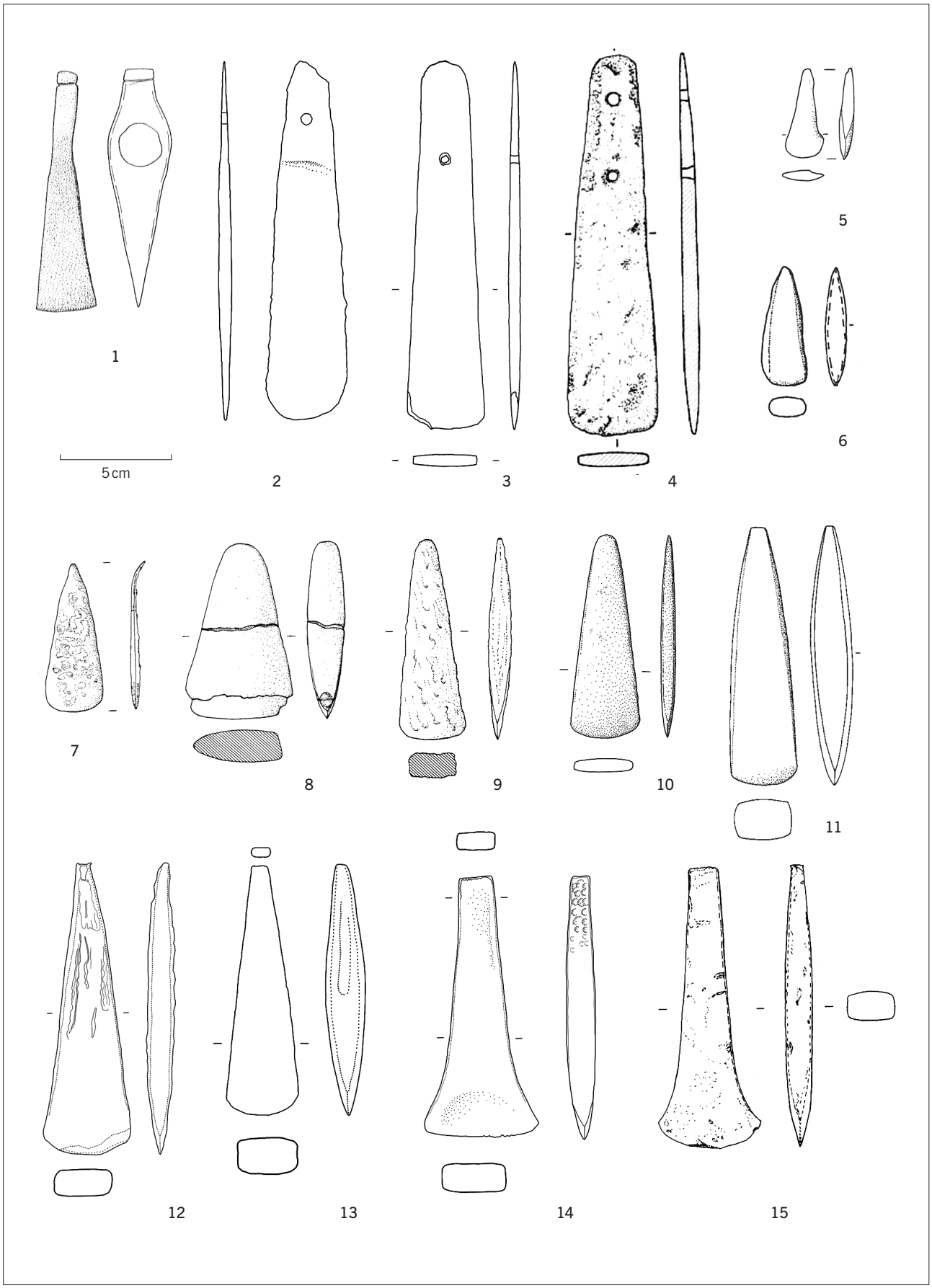


Fig. 6 Copper-alloy axes from north-central Italy assigned by Iaia/Dolfini (2021) to Horizon 1 (Late/Final Neolithic, 4300/4200–3750/3650 BC) based on typological, technological, or contextual grounds.

Abb. 6 *Nordmittelitalienische Beile aus Kupferlegierung, die von Iaia/Dolfini (2021) aus typologischen, technologischen oder kontextuellen Gründen dem Spät-/Endneolithikum (4300/4200–3750/3650 v. Chr.) zugeordnet werden.*

Fig. 7 Grave goods from Rinaldone, Lazio, tomb 3. The assemblage, comprising a copper-alloy halberd, two flat axes, and three leaf-shaped daggers (two shown) is dated on typological grounds to the mid-4th millennium BC; no scale.

Abb. 7 *Beigaben aus Rinaldone, Latium, Grab 3. Das Inventar mit einem Stabdolch aus einer Kupferlegierung, zwei Flachbeilen und drei blattförmigen Dolchen (zwei im Bild) datiert typologisch in die Mitte des 4. Jts. v. Chr.; o. M.*

c. 4500–4350 BC (Mazzieri/Dal Santo 2007; Visentini 2005; see also Dolfini 2013a, Tab. 3). A group of archaic-looking axes of elongated, triangular, or trapezoidal shape are also assigned to this horizon despite the lack of radiocarbon dates (Fig. 6). However, many of these implements are morphologically akin to Neolithic groundstone axes, whose circulation peaked in the late 5th and early 4th millennia BC (Pétrequin et al. 2012). Moreover, they often display technological traits indicating poor mastery of copper casting, e.g., rough surfaces caused by lack of control of thermal gradients and oxygen ingress in the mould. This is another marker of incipient metallurgy (Giardino 2012). Finally, associated finds, where available (e.g., four greenstone axes from Boschetti di Chiozza, Emilia-Romagna, and two obsidian cores from Sgurgola-Casali, Lazio; Dolfini 2013a; Pearce 2007, 38–46), further support a Late or Final Neolithic chronology for these axes. Morphological and technological *comparanda* with Central Europe corroborate the impression that, overall, these axes should be dated to 4300/4200–3750/3650 BC (Kienlin 2008, 98; Klassen 2010; Nielsen 2016, 152).

Horizon 2: Early Copper Age (3650–3350 BC)

This horizon marks the earliest use of metal objects in Rinaldone-style burials, west-central Italy, which define new mortuary behaviours and social identities (Dolfini 2020; Dolfini 2021). New types of flat, trapezoidal axes were first made in this period, as well as the earliest daggers and halberds (Fig. 7; see also Horn 2014). These objects were cast and worked by smiths who, unlike their Neolithic forebears, expertly controlled metallurgical processes to obtain thin artefacts with smooth, shiny surfaces. Interestingly, Horizon 2 is solely documented in the west-central peninsula. A handful of objects from east-central and southern Italy might belong to this period, but they are few and poorly dated. Virtually no metals are recorded in northern Italy. This is an original finding of Iaia and Dolfini's research, which was hidden by the coarser-grained, and partly incor-

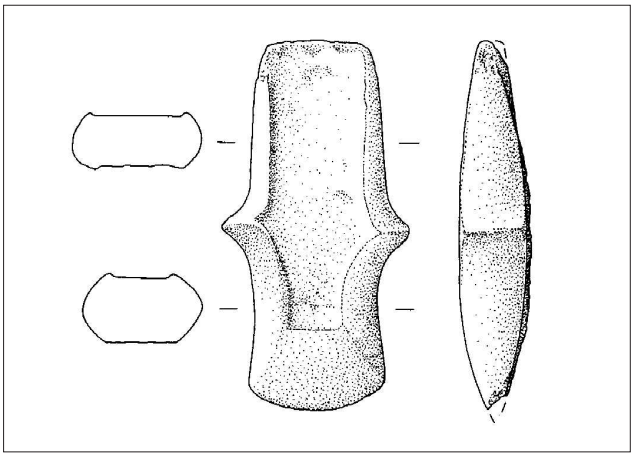


Fig. 8 Axe of the ›Mirabella Eclano‹ type from the hinterland of Terni, Umbria, central Italy. Axes of this kind were extensively hammered into shape before use, as shown by the markedly rounded margins of this specimen. Length: 10.50 cm.

Abb. 8 *Beil vom Typ Mirabella Eclano aus dem Hinterland von Terni, Umbrien, Mittelitalien. Beile dieser Art werden vor Gebrauch ausgiebig in Form gehämmert, wie an den deutlich gerundeten Rändern dieses Exemplars zu sehen ist. Länge: 10,50 cm.*

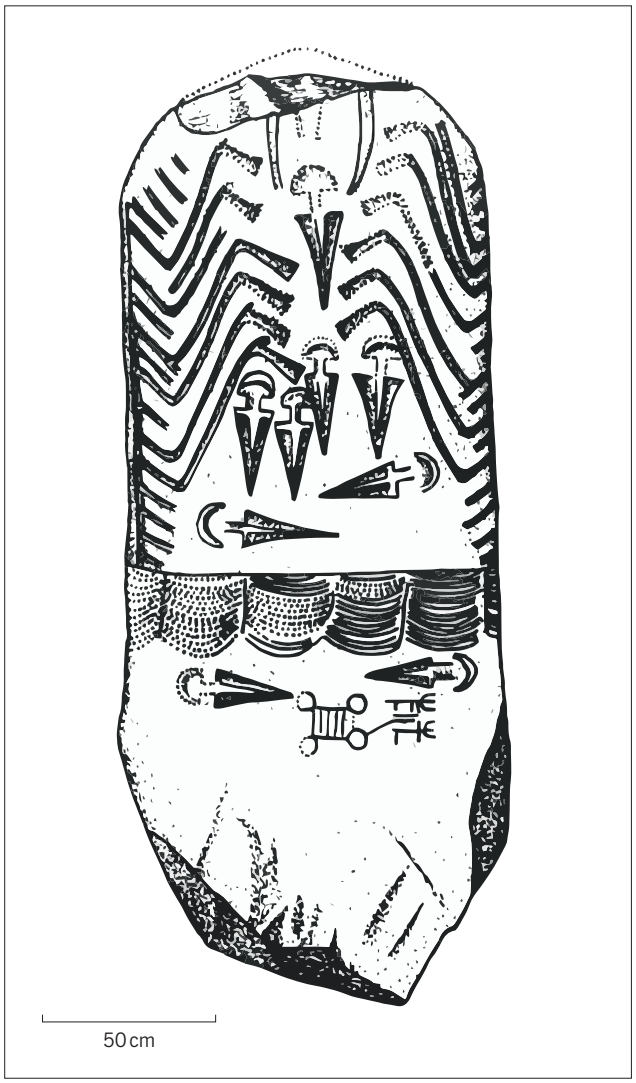


Fig. 9 Anthropomorphic stela from Lagundo, South Tyrol, south-eastern Alps, displaying an array of metal axes and Remedello-type daggers. Height: 2.75 m. Alpine stelae typically display rich assemblages of metal weapons and tool-weapons that are rarely found at contemporary sites from the region.

Abb. 9 *Anthropomorphe Stele aus Algund, Südtirol, Südostalpen, mit einer Vielzahl dargestellter Metallbeile und Dolche vom Remedello-Typ. Höhe: 2,75 m. Stelen aus den Alpen zeigen typischerweise eher umfangreiche Zusammenstellungen von Metallwaffen und Werkzeugwaffen, welche an den zeitgenössischen archäologischen Fundplätzen der Region jedoch selten zu finden sind.*

rect, chronologies of old. Further research is needed to clarify why metals all but disappeared from northern Italy at the end of the Neolithic. It is unclear whether this is a visibility bias due to prevalent collective burials, which did not dictate the use of metalwork to define individual identities in death, or a real hiatus in metal production.

Horizon 3: Middle Copper Age (3350–2900 BC)

This horizon heralds a new phase in metalwork production and consumption all over Italy, except perhaps in the far south and Sicily. It also marks the birth of regionally differentiated technological styles defining the typical metallurgical (and funerary) traditions of Copper Age Italy, namely ›Remedello‹ in the north (Lombardy) and ›Gaudo‹ in the south-west (Campania; the ›Rinaldone‹ tradition first emerged in Horizon 2). The smelters and smiths active in west-central Italy during Horizon 2 likely played a key role in transmitting metallurgical knowledge further north and south in this period. Although initially imported, the craft rapidly took hold in these areas, as indicated by locally invented object designs and metalworking techniques. In northern Italy, for example, smiths often hammered axe margins to ensure a better grip between blade and haft – a technological development that will eventually lead to the invention of flanged axes. Hammer-shaping and working were also practised in central and southern Italy, as evidenced by distinctive ›Mirabella Eclano-type‹ axes (Fig. 8).

Horizon 4: Late Copper Age (2900–2700/2600 BC)

This horizon features far fewer dated burials than either Horizon 2 or 3, hence the uncertainty with the lower boundary. The waning of metal objects from mortuary sites seems to reflect changing ideas of the dead in 3rd millennium BC Italy. Metal-rich male and female burials are now rarer, especially in west-central and southern Italy, but less rare in the north. However, metal objects have been found, albeit in small numbers, at Laterza-style cemeteries in south-eastern Italy. Technologically, this horizon exhibits a great deal of continuity in axe design and manufacture with the previous period. However, the picture is likely skewed by a visibility bias obscuring the many metals that ended their social lives in a melting pot rather than in burials. This is suggested, *inter alia*, by 3rd millennium BC Alpine stelae displaying rich panoplies of metal tools and weapons not found in contemporary Alpine burials (Fig. 9).

Horizon 5: Final Copper Age (2700/2600–2200/2100 BC)

The decline in the visibility of metal objects begun in Horizon 4 accelerated during this period, with significant implications for our ability to assess the character of metal production and consumption and to date it through radiocarbon. Europe-wide connectivity is apparent in new Beaker-style objects, while Cetina-style metals (and pottery) highlight cross-Adriatic contacts. Both communication channels are evident in grave assemblages from Gaudello, a late 3rd millennium BC burial site in the Bay of Naples (Fig. 10; Mancusi/Bonifacio 2020). Flanged axes became ubiquitous during Horizon 5 thanks to continuing technological developments, which can be traced back to the thickening of axe margins in 4th millennium BC Italy (see above). For the first time, metal objects were deposited in hoards as well as graves. The earliest Italian hoards (i.e., Col del Buson, Veneto, and Pigloner Kopf, South Tyrol; Bianchin Citton 2013; Oberrauch 2014) are comparatively small, but the new practice gained momentum rapidly. By 2200/2100 BC, hoarding had acquired the character that will define it throughout the Early Bronze Age, as seen at Remedello Sopra, Lombardy (de Marinis 1979; de Marinis 2012). This hoard marks the transition between the Copper and Bronze Ages.

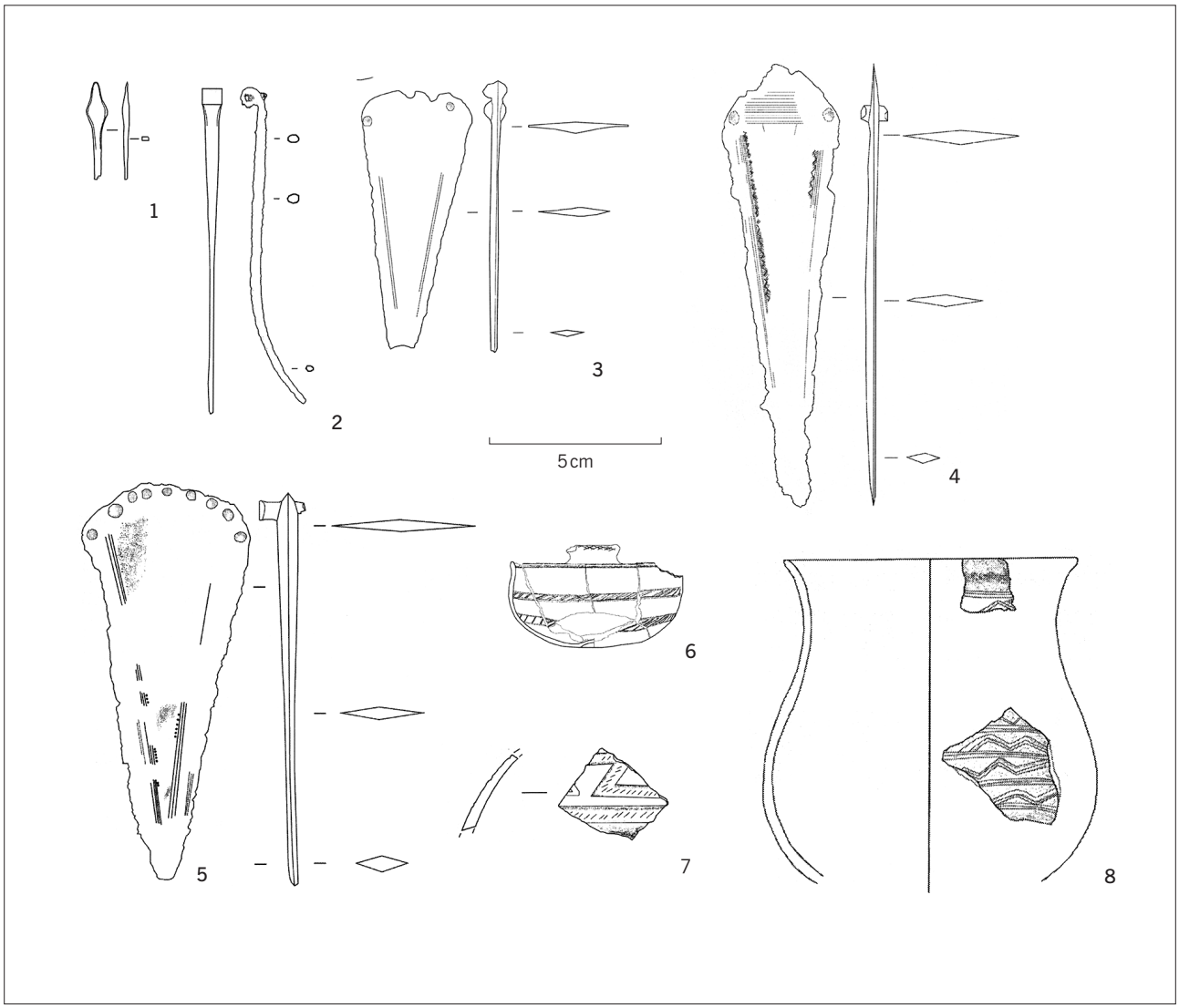


Fig. 10 Selected metal and ceramic artefacts from Gaudello, Campania, a late 3rd millennium BC burial site near Naples.

Abb. 10 *Ausgewählte Metall- und Keramikartefakte aus Gaudello, Kampanien – einem Bestattungsplatz des mittleren/späten 3. Jt. v. Chr. in der Nähe Neapels.*

Production

Early Italian metallurgy focused on the manipulation of several substances including copper, arsenical copper, silver, and antimony. Italian smiths also manipulated a ternary copper alloy containing between 1–5 wt % arsenic *and* antimony, plus detectable silver. However, they did not employ gold or gold-silver alloys, which are not found anywhere in Italy before the Bronze Age. Interestingly, while most of the metallic substances described above are found all over Italy, ternary copper-arsenic-antimony alloys and unalloyed antimony are typical of central Italian metallurgy. Chronologically, all these copper alloys were in use from the mid-4th millennium BC until the early 2nd millennium BC, when they were progressively replaced by tin-bronze.

The Stuttgart programme and other wide-ranging programmes of metal analysis carried out in the 20th century have shed light on the chemical composition of early Italian metals[3]. Overall, the chemical data show that axes were typically made from low-impurity copper, whereas daggers and halberds were cast using arsenical copper and, in central Italy, arsenical and antimonial copper. Awls, pins, and wire rings were apparently cast from any copper alloys (although data are scarce), while perforated beads and other personal ornaments were made from either silver or, in central Italy, antimony (Tab. 1). Exceptions are very few, e.g., two 3rd millennium BC objects – a ring and a bead – made of tin-bronze, perhaps naturally obtained from copper-tin ores (Dolfini 2014, 478). Newer chemical analyses have not changed the picture significantly, except for highlighting that axes are more varied in

3 Barker 1971; Junghans et al. 1960; Junghans et al. 1968; Junghans et al. 1974; Otto/Witter 1952.

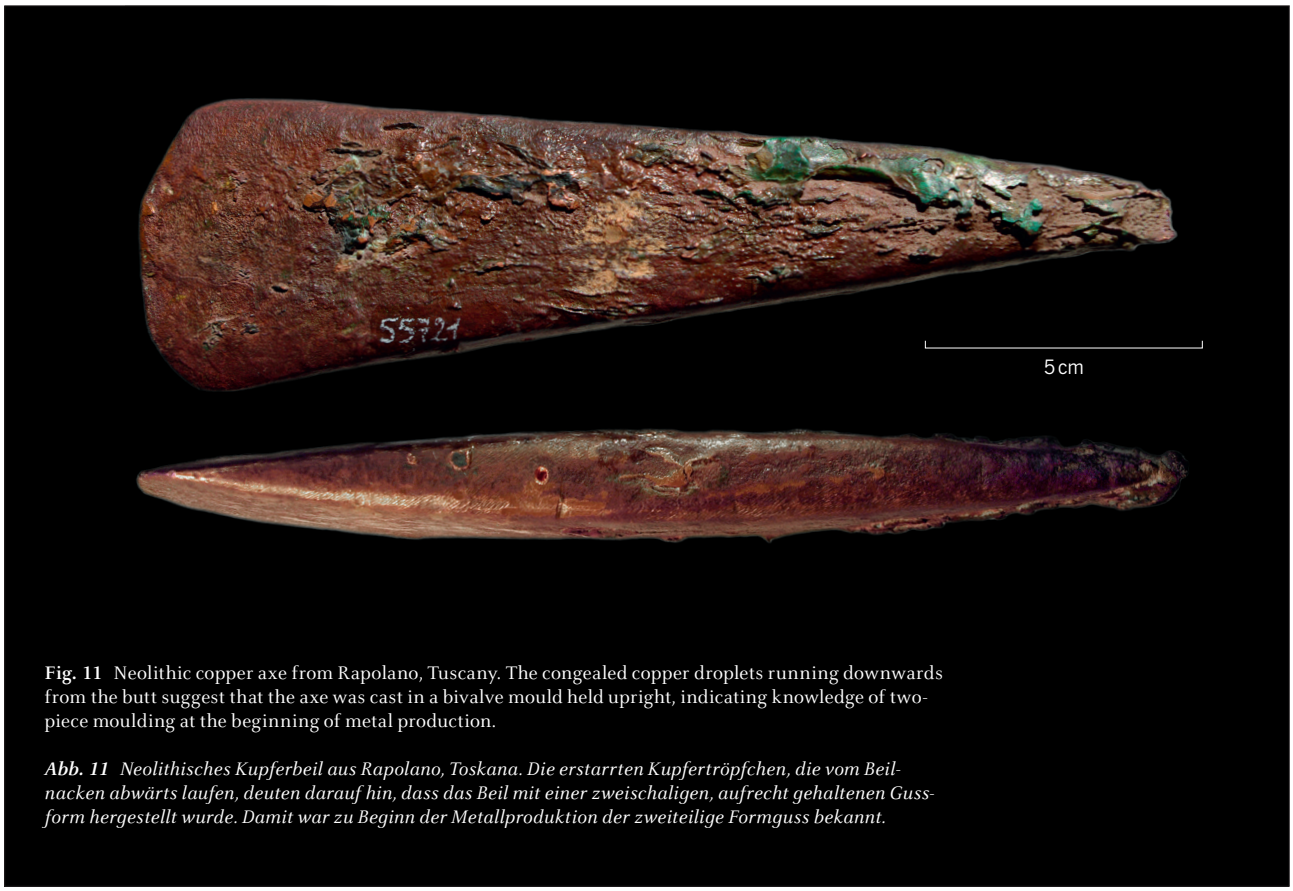


Fig. 11 Neolithic copper axe from Rapolano, Tuscany. The congealed copper droplets running downwards from the butt suggest that the axe was cast in a bivalve mould held upright, indicating knowledge of two-piece moulding at the beginning of metal production.

Abb. 11 *Neolithisches Kupferbeil aus Rapolano, Toskana. Die erstarrten Kupfertröpfchen, die vom Beilnacken abwärts laufen, deuten darauf hin, dass das Beil mit einer zweischaligen, aufrecht gehaltenen Gussform hergestellt wurde. Damit war zu Beginn der Metallproduktion der zweiteilige Formguss bekannt.*

METALLIC SUBSTANCE	NORTHERN ITALY	PENINSULAR ITALY
low-impurity copper	axes, awls, rings	axes, awls, rings
arsenical copper	daggers, halberds, awls, a few axes	daggers, halberds, awls, a few axes
arsenical/antimonial copper	none	daggers, halberds, awls, a few axes
silver	beads, pin heads	beads, pin heads
antimony	none	beads

Tab. 1 Synopsis of the main metallic substances used in northern and peninsular Italy during the Copper Age, c. 3650–2200 BC. Specific metallic substances were employed in this period for the fabrication of distinct categories of utilitarian and ornamental artefacts, revealing the techno-cultural categorisation principles that guided prehistoric metallurgical processes.

Tab. 1 *Zusammenfassung der wichtigsten metallischen Materialien, die in Norditalien und auf der Apenninhalbinsel in der Kupferzeit, ca. 3650–2200 v. Chr., Verwendung fanden. Für die Herstellung unterschiedlicher Kategorien funktioneller und dekorativer Artefakte griff man in dieser Periode auf ganz bestimmte metallische Materialien zurück. Dies legt die strengen technokulturellen Kategorisierungsprinzipien offen, die in der Vorgeschichte der Steuerung metallurgischer Prozesse dienten.*

their alloy compositions than daggers and halberds, with several featuring over 1 wt % arsenic and/or antimony[4].

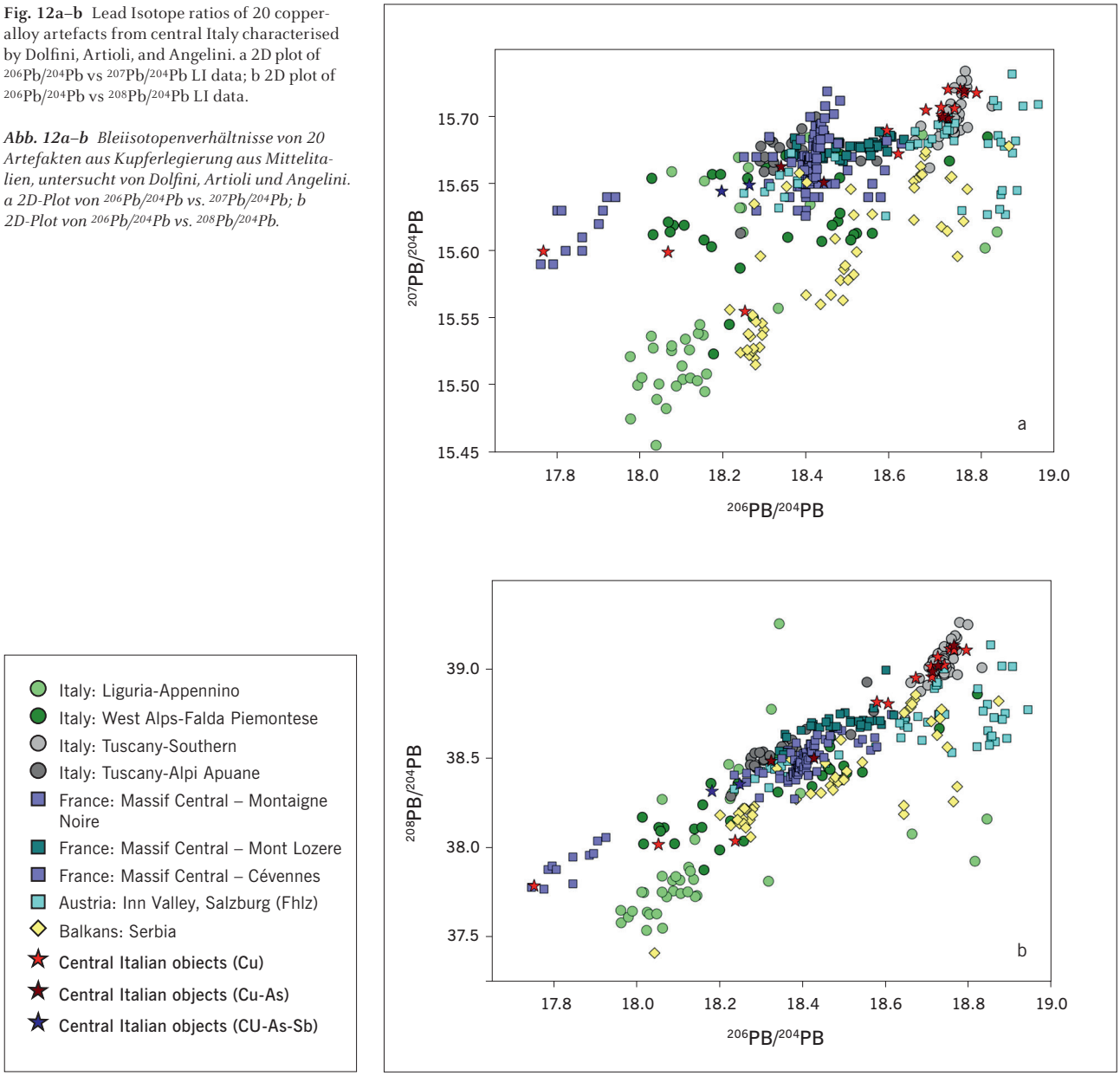
Several studies employing optical/digital microscopy and neutron diffraction have shed light on axe casting and forging technology. Giardino (2012) examined two Neolithic axes from central Italy. He observed patterns of wrinkles stretching along the vertical planes of the objects and, in one specimen, congealed copper droplets running downwards from the butt, seemingly caused by the mould cracking under thermal stress (Fig. 11). Both features, which he reproduced experimentally, demonstrate that bivalve moulds were already in use at the beginning of copper metallurgy. It is unclear, however, whether these axes were cast locally or were imported from the Balkans, as they well might have been (see below).

In two separate studies, Dolfini and Iaia observed 28 Copper Age axes, mostly from central Italy (Dolfini 2011; Iaia/Dolfini 2020). They detected characteristic casting defects that can only be obtained in bivalve moulds, such as (1) hollowed-out faces and blowholes (on both faces of

4 Carboni 2020; De Marinis 2006; Dolfini 2008; Dolfini 2014; Giardino 2000.

Fig. 12a–b Lead Isotope ratios of 20 copper-alloy artefacts from central Italy characterised by Dolfini, Artioli, and Angelini. a 2D plot of $^{206}Pb/^{204}Pb$ vs $^{207}Pb/^{204}Pb$ LI data; b 2D plot of $^{206}Pb/^{204}Pb$ vs $^{208}Pb/^{204}Pb$ LI data.

Abb. 12a–b *Bleiisotopenverhältnisse von 20 Artefakten aus Kupferlegierung aus Mittelitalien, untersucht von Dolfini, Artioli und Angelini. a 2D-Plot von $^{206}Pb/^{204}Pb$ vs. $^{207}Pb/^{204}Pb$; b 2D-Plot von $^{206}Pb/^{204}Pb$ vs. $^{208}Pb/^{204}Pb$.*



axes) caused by gases trapped within the mould, and (2) V-shaped shrinkages on axe butts, which were caused by an insufficient amount of metal being used for the cast (Dolfini 2014, Fig. 18.7). These features point to the widespread usage of bivalve moulds in 4th and 3rd millennia BC Italy. Axes cast in monovalve moulds (as suggested by profile asymmetry) are present in the sample in limited numbers. This goes against received wisdom postulating that ›more advanced‹ bivalve moulds would have followed early experimentations with ›simpler‹ monovalve ones. Emphatically, the data show that two-piece and one-piece moulds were used side by side in early Italy, the former to produce axe-blades that were then hafted perpendicularly as wood-cutting tools (or axes proper), and the latter to be cross-hafted as wood-carving tools (or adzes).

Furthermore, these studies revealed features caused by hammer-shaping and forging, such as thickened or flattened margins, raised flanges, sharp bevels between tool body and cutting edge, and elongated hammer marks denoting edge-hardening (Dolfini 2011; Iaia/Dolfini 2020). Shaping and forging practices were also investigated by G. Artioli (2007) through the neutron diffraction analysis on 20 axes from northern Italy, including Ötzi the Iceman's axe. He noted that most objects had been slightly mechanically worked after casting and then partially annealed. Of the remainder, two axes display near-complete thermal recrystallisation, two (including the Iceman's axe) were left as-cast, and three show peculiar textures that may be produced by extremely slow cooling after casting.

Interestingly, most of the objects examined by Artioli fall into similar parameters as Chalcolithic axes from the northern Alps, which typically underwent a cycle of cold-working and annealing but were rarely work-hardened afterwards (Kienlin 2008; Kienlin 2010). However, while most north-Alpine axes were fully recrystallised through extensive annealing, recrystallisation is only partial in the Italian axes. According to Artioli (2007), this indicates that hammering and annealing were not primarily intended to

harden the tools, but to shape them after casting. Overall, the data show that, indeed, early Italian smiths had sound knowledge of copper casting and processing, but they were either unable or uninterested in optimising tool performance through edge-hardening.

Exchange

Several Lead Isotope (LI) studies of axes, daggers, halberds, and awls have been conducted in recent years, illuminating copper procurement and exchange networks in early Italy. The discussion below is grounded in the analysis of all these objects, rather than solely axes, to better contextualise prehistoric axe exchange.

Artioli and his team isotopically characterised three Late/Final Neolithic awls from northern Italy, dating to the late 5th and early 4th millennia BC (Artioli et al. 2020). Two awls have LI signatures compatible with Balkan copper sources, suggesting importation from present-day Serbia and Bulgaria rather than local production. The third object, from Arene Candide in western Liguria, might derive from Roua, a native-copper mine in the south-western Alps (Bussone 2023; Campana et al. 1996).

In a further study, Artioli's team characterised 49 axes from north-central Italy, including several specimens dating to the Late/Final Neolithic (Artioli et al. 2024). The analysis revealed that virtually all Neolithic axes were made from Bulgarian, Serbian, or (in one case) Romanian copper, bolstering the scarce data provided by early awls. Overall, the LI data indicate that Neolithic Italian metals were overwhelmingly imported from the Balkans. This corroborates the impression that the birth of Italian metallurgy was instigated by knowledge exchange with this region (Dolfini 2013).

As part of the same study, Artioli's team also characterised numerous Copper Age axes. The LI data seem to delineate two pulses of ore extraction, the first centring on Tuscany and the second on the south-eastern Alps, with the caveat that the chronology of certain objects is unclear. Initially, in the mid/late 4th millennium BC, axes were cast using Tuscan copper from the Ore Mountains and adjacent sources. Most of this copper stayed in west-central Italy, until it started to travel north in the late 4th and early 3rd millennia BC, as indicated by a few axes from Remedello, Lombardy and Celletta dei Passeri. The Iceman's axe and the axe from Zug-Riedmatt in the Swiss Alps – both dating to the late 4th millennium BC – were also made from Tuscan copper (Artioli et al. 2017; Gross et al. 2017). Subsequently, copper mined in the south-eastern Alps started circulating, and its exploitation gained momentum in the mid/late 3rd millennium BC. Not only is this shown by the LI signals of northern Italian and Alpine axes, but also by copper-smelting evidence from the region (Artioli et al. 2015; Pearce et al. 2022). Tuscan copper is no longer found north of the Apennines at this time, although the sample size is small for this chronological bracket and future research might yet change the picture.

In a separate study, Dolfini et al. (2020) isotopically and chemically characterised 20 Copper Age objects from central Italy, including 14 axes, three daggers, and three halberds. Eleven objects were ostensibly made from Tuscan copper, four have LI ratios falling within an area of overlapping ore fields, four are consistent with western and south-western Alpine deposits, and one unexpectedly derives from the Massif Central, southern France (Fig. 12). Interestingly, two of the objects with non-Tuscan LI fingerprints have a high-arsenic, high-antimony alloy composition that is otherwise typical of central Italian metalwork (see above). This suggests that copper with this distinctive chemistry might originate from the western or south-western Alps and not from Tuscany, as was generally postulated until recently.

In conclusion, the LI data discussed above suggest that Italy and the southern Alps were intersected by the three discrete networks for the procurement and exchange of copper, which operated largely independently from one another in different phases, from the Late/Final Neolithic to the Late/Final Copper Age (Fig. 13):

1. **Balkan network, 4500–3650 BC**. Axes and awls crafted from Balkan (mainly Serbian and Bulgarian) copper moved into north-central Italy and the Alps from c. 4500–4300 BC. This is consistent with metal from the same sources circulating widely throughout Eastern and north-central Europe in the same span of time[5]. It is tempting to suggest that knowledge of copper metallurgy moved with the objects, instigating ore extraction and metalworking in 4th millennium BC Tuscany.
2. **Tyrrhenian network, 3650–2200? BC.** The copper sources of the Tuscan Ore Mountains began to be exploited in the mid-4th millennium BC (and perhaps earlier, if the chronology of Orti Bottagone, the smelting site discussed above, is correct). The LI data are supplemented by ore-smelting evidence from San Carlo and ore-mining evidence from Libiola and Monte Loreto, both Liguria, although this copper has not yet been identified isotopically in any objects. Initially, Tuscan copper may not have moved far from its sources. By 3350/3100 BC, however, a sprawling exchange network had emerged, which encompassed west-central Italy, the western and south-western Alps, and the French Midi. Corsica and south-western Italy might also have been part of the network. While most of the copper apparently circulated within the network, certain objects travelled further north and north-east, well into the Alps. The people carrying these objects might have transmitted the skills needed to reduce copper from the rich sulphide deposits of Trentino and Alto Adige/South Tyrol.
3. **South-eastern Alpine network, 2600/2500–2200 BC.** It is unclear when the ore bodies of the south-eastern Alps were first exploited. Although most smelting sites date to the mid/late 3rd millennium BC, certain objects made from this metal might be earlier (Artioli et al. 2024). At any rate, by c. 2500 BC, south-eastern Alpine copper was extensively mined, smelted, and exchanged throughout

5 Artioli et al. 2024; Brozio et al. 2023; Nørgaard et al. 2019; Nørgaard et al. 2021.

Fig. 13 Approximate range and duration of the copper procurement and exchange networks discussed in the paper. The arrows indicate individual objects travelling beyond the network's typical range.

Abb. 13 *Ungefährer Bereich und Zeitraum der im Beitrag besprochenen Kupferbeschaffungs- und -tauschnetzwerke. Die Pfeile weisen auf einzelne Objekte hin, die über den netzwerktypischen Bereich hinaus transportiert wurden.*

the eastern Alps and north-eastern Italy. Occasionally, objects travelled further north (Brozio et al. 2023; Nørgaard et al. 2019; Nørgaard et al. 2021) – an intimation of the wide-ranging metal exchange networks that were to flourish in Bronze Age Europe.

Use

In recent years, the application of traceological analysis to copper-alloy objects – or metalwork wear analysis (Dolfini/Crellin 2016) – has provided valuable insights into the uses of early Italian axes. The analysis has revealed recurring use traces, which mostly fall into the three categories described below (the data refer to the same 28 Copper Age axes previously discussed for their manufacturing technology; Dolfini 2011; Iaia/Dolfini 2020).

1. Series of micro-indentations, or ›nicks,‹ on the cutting edge (Fig. 14). These traces frequently cluster on one-half of the cutting edge, indicating that (a) the blade was fixed perpendicularly to the handle, thus used as an axe proper, rather than an adze; and (b) it was hafted with the worn portion down. Woodcutting experiments demonstrate that the lower cutting edge wears out faster and more substantially than the upper edge (Dolfini et al. in press; Kienlin/Ottaway 1998; Roberts/Ottaway 2003). Therefore, the lower edge gets resharpened more often, causing over time a noticeable asymmetry in the tool's profile (Moyler 2008). Conversely, evenly spread indentations all over the

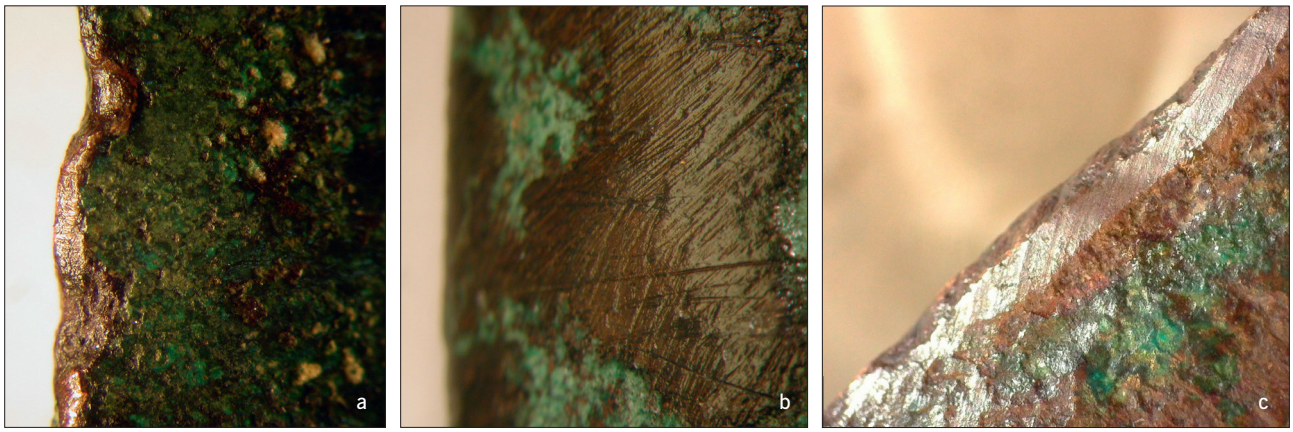


Fig. 14a–c Use-wear traces observed on the cutting edges of three Copper Age axes from Italy. a Series of micro-indentations interpreted as woodcutting traces; b overlapping patterns of striations also interpreted as woodworking traces; c series of short, closely spaced, and angled striations interpreted as sharpening traces.

Abb. 14a–c *Gebrauchsspuren an den Schneiden dreier kupferzeitlicher Beile aus Italien. a Reihe von Mikroeinkerbungen, die als Holzfällspuren interpretiert werden; b sich überlappende Riefenmuster, ebenfalls als Spuren der Holzbearbeitung interpretiert; c Reihe kurzer, enger und schräger Riefen, die als Wetzspuren interpretiert werden.*

cutting edge suggest that the axe blade may have been turned over and re-hafted at some point during its life cycle.

2. Patterns of striations running either at a right angle or slightly inclined to the cutting edge and extending no more than 2 cm into the tool's body. These traces also develop due to contact with wood (Dolfini et al. in press; Kienlin/Ottaway 1998; Roberts/Ottaway 2003). When found side by side on the same object, micro-indentations and striations provide compelling evidence that the axe was used to fell trees and cut wood, much like a modern axe.
3. Patterns of tight, short, and highly orientated striations extending only a few millimetres (or less) back from the cutting edge. Unpublished experiments with replica tools suggest that these traces develop when axe blades are sharpened with a whetstone.

Use-wear analysis reveals a broader range of use traces than the ones described above, both in Italy and elsewhere (e.g., Crellin 2018). These include flattened or bent cutting edges, notches, and small cracks, which may be challenging to interpret due to their unspecific character or lack of targeted experimentation. There is little doubt, however, that most of these traces originate from protracted friction or impact against hard materials. Occasionally, major faults and fractures are visible on axe cutting edges (Fig. 15). Such extreme instances of material failure indicate that the tool was used until the metal turned brittle and cracked. This suggests a knowledge gap between axe makers, who could address metal brittleness by annealing the tool, and axe users, who would sometimes overwork the tool until it failed.

One of the most intriguing results of use-wear analysis is the realisation that most Italian axes had been used during their social lives. This suggests that axes had important utilitarian values in the realms of woodcutting and carpentry. However, the data also reveal considerable variation in the degree of use–wear, ranging from very little to very extensive, including, occasionally, tools damaged beyond repair. This highlights that (a) the lifespan of axes varied greatly from object to object and possibly ranged from manufacture for immediate use as grave goods to long-lasting cycles of use, exchange, and inheritance; and (b) deposition practices were arguably grounded in cultural choices, which did not have any direct relationship with the use history of tools. These practices are explored in the next section.

Deposition

As part of his doctoral research, Dolfini (2008) compiled a database of Neolithic and Copper Age metalwork from central Italy, comprising, at the time of its completion, 409 objects (mostly axes, daggers, and halberds). Searching the database sheds light on metalwork deposition practices in prehistoric Italy.

Domestic sites account for a small fraction of archaeologically recovered metals (23 objects, or 5.6 % of the overall sample). Among these, only five are axes, suggesting that this was not a significant context for the formal placement of these objects – or, indeed, of any metal objects. Hoarding cannot be considered a significant cultural practice either, given the complete absence of Copper Age hoards in central Italy (although two 3rd millennium BC hoards do exist in north-eastern Italy, at Col del Buson and Pigloner Kopf; Bianchin Citton 2013; Oberrauch 2014). Overall, metalwork hoarding gained significance as a social practice only in the Early Bronze Age (De Marinis 2006; Peroni 1996).

By contrast, large numbers of axes are classified in the database as stray finds or finds from unknown contexts. A review of the literature suggests that some of these objects may originate from looted or destroyed graves. Many others, however, were apparently discovered in the landscape as isolated finds. This implies that, in Copper Age Italy, metal axes were often placed at culturally salient locales in

the open landscape, perhaps to mark out significant events or ritual actions. Interestingly, axes were overwhelmingly singled out for this behaviour, whereas daggers and other metal objects were very rarely placed in the landscape, if at all. Arguably, this demonstrates continuity with the Neolithic practice of ritually depositing ground stone axes away from settlement sites (Robb 2007, 213).

The other practice emerging as prevalent in the database is the formal placement of axes (and other metal objects) in burials. Throughout Italy, the 4th and 3rd millennia BC saw the emergence of formalised, regionally specific burial traditions named after the prototypical sites of Remedello, Lombardy (in the north), Rinaldone, Lazio (in the centre), Gaudo, Campania (in the south-west), and Laterza, Apulia (in the south-east). These traditions stand out among the diverse burial behaviours practised throughout Italy for their frequent emphasis on individual burial, in which significant elements of the deceased's identity – gender, age, and perhaps rank – were highlighted through normative sets of metal and non-metal goods (Dolfini 2015; Dolfini 2020, with references).

The most conspicuous male burials – often termed ›warrior graves‹ – display rich assemblages of weapons and tool-weapons (Fig. 16). Their interpretation followed the changing theoretical paradigms of 20th century archaeology. In the heyday of culture history, V. G. Childe (1957) and S. M. Puglisi (1959) posited that these burials would provide evidence of invading warrior-shepherds from the Orient. Peroni (1971; Peroni 1996) later retorted that they should instead be seen as the indigenous precursors of Bronze Age warring aristocracies. In the processual era, Barker (1981) claimed that these burials would signal the rise of social rank, whereas A. Cazzella (1992; Cazzella 1998), J. E. Robb (1999; Robb 2007), and others (e.g., Dolfini 2004; Dolfini 2006) argued that these were ›Big Men‹ who had achieved lifetime power through peer competition for metals and other exotica.

In a recent journal article, Dolfini (2021) proposed an alternative interpretation for Rinaldone-style warrior graves and other lavishly equipped burials. He noted that (a) the scarcity of metalwork at collective and reorganised burials may result from the deliberate removal of these objects during extended funerals, rather than an actual shortage of metal or its appropriation by emerging elites; (b) the analogy with ›Big Man‹ societies from world ethnography and ethno-history may not be the most appropriate to explain prehistoric Italian society; and (c) modern ideas of the individual person are likely a poor guide to understanding mortuary practices in non-Western societies, in which notions of diffused and relational personhood often prevail (Brück 2004; Fowler 2004; Fowler 2018). These considerations challenge predominant interpretations of metal-rich male burials as prehistoric high-ranking individuals.

In the same article, Dolfini argued that these burials might have been afforded to people marked out by uncommon life or death circumstances, e.g., killers or the victims of homicide, or members of the community with stigmatised, or perceived dangerous, identities. This interpretation is supported by intriguing, if circumstantial, evidence, including (a) notable rates of peri-mortem injuries in equipped individual burials; (b) unusual funerals (e.g., chamber graves sealed with massive slabs, as if to close in a dangerous being; Fig. 17); and (c) the very weapons typically found in these graves, which should not be considered as the personal possessions of self-aggrandising tribal leaders but as material mementos of the deceased's most salient deeds and social relations (Dolfini 2021). It would be interesting to see whether this reading may also apply to other single-burial traditions of Chalcolithic and Early Bronze Age Europe, e.g., Beaker burials.

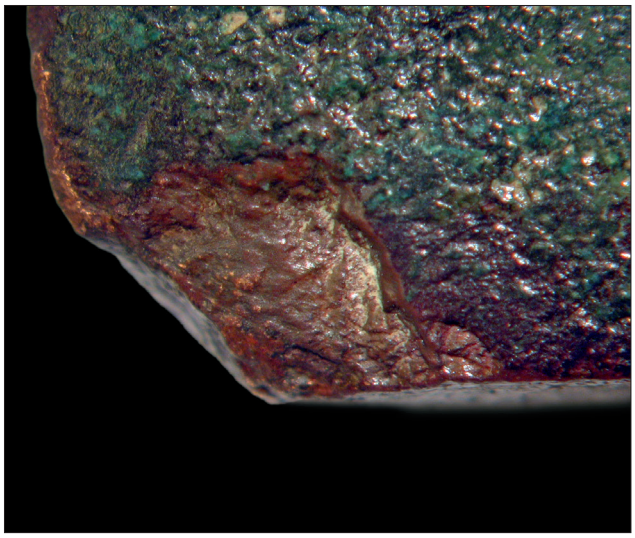


Fig. 15 Metal failure due to accumulated brittleness on the cutting edge of a Copper Age axe from central Italy.

Abb. 15 *Metallermüdung aufgrund kumulativer Sprödigkeit an der Schneide eines kupferzeitlichen Beils aus Mittelitalien.*

Conclusion: The social value of early Italian metal axes

Several conclusions about the social value of early Italian axes can be drawn from the data and interpretations reviewed above. Firstly, very few clear-cut categories of metal objects were manufactured and used in Copper Age Italy (c. 3650–2200 BC) following the importation of selected objects from the Balkans in the Late/Final Neolithic (c. 4500–3650 BC). Axes are most conspicuous among them, alongside daggers and halberds. Intriguingly, object categories were defined not only morphologically, but also through distinctive metallic substances. Axes were predominantly cast from low-impurity copper, while daggers and halberds were made from either arsenical or arsenical/antimonial copper, and ornaments from either silver or antimony. This indicates that metals were crafted in adherence to shared cultural expectations regarding the shape, appearance, and intended consumption pathway of each object category.

Secondly, traceological data suggest that axes were typically used to fell trees, cut wood, and hew and carve timber. However, most tools were not disposed of when unserviceable, but at a point in their life cycles presumably dictated by quintessentially social circumstances – for instance, the death of their owner or some other event worth commem-

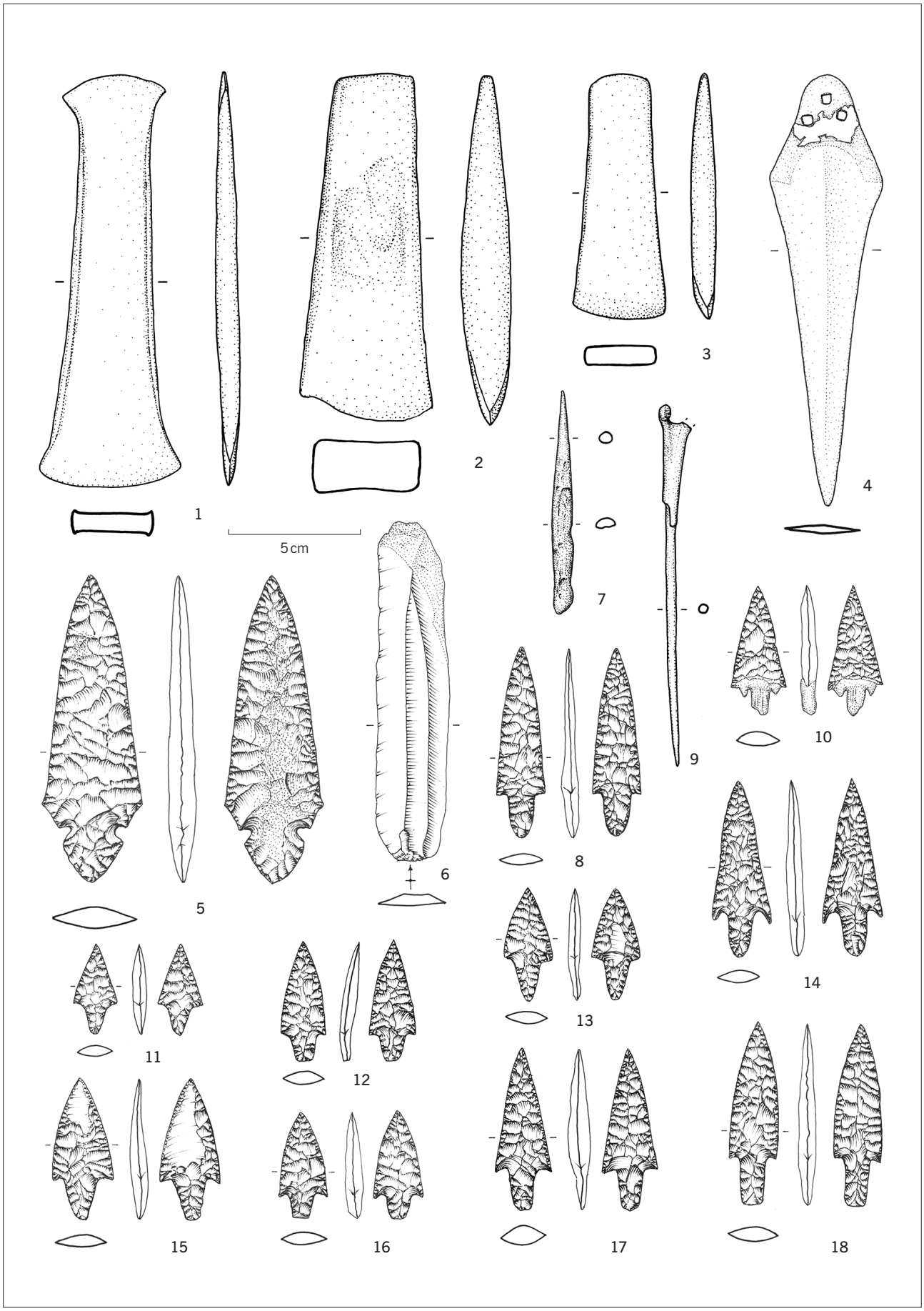


Fig. 16 Grave goods from Casetta Mistici, Lazio, tomb 8. The assemblage is typical of richly equipped ›warrior burials‹ from central Italy.

Abb. 16 *Beigaben aus Casetta Mistici, Latium, Grab 8. Das Inventar ist typisch für eine reich ausgestattete »Kriegerbestattung« aus Mittelitalien.*

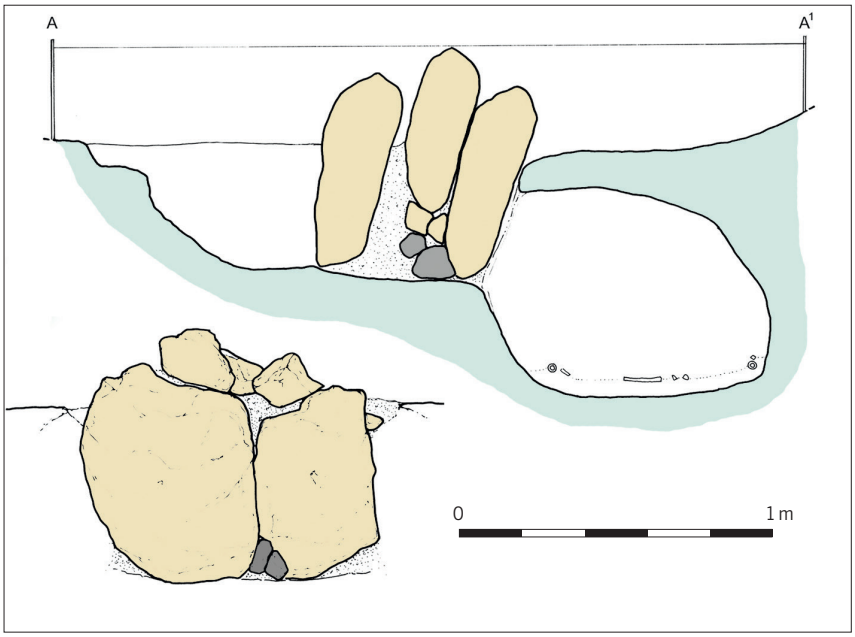


Fig. 17 Cross-section and frontal view of Casetta Mistici, Lazio, tomb 7. This chamber tomb, containing the articulated remains of a woman who had died a violent death, was sealed with massive stone slabs as if to close in a »dangerous being«.

Abb. 17 *Querschnitt und Frontalansicht von Casetta Mistici, Latium, Grab 7. Dieses Kammergrab mit den im Verbund niedergelegten Überresten einer Frau, die eines gewaltsamen Todes gestorben war, wurde mit großen Steinplatten verschlossen, so als wollte man ein »gefährliches Wesen« einschließen.*

orating. The fact that axes were predominantly deposited either in the open landscape or in burials further underscores the deliberate, and indeed ritual, nature of prehistoric metal deposition practices.

Finally, a review of find contexts highlights that funerals constituted the most significant social arena for formally depositing metal axes at the end of their life cycles. These tools were primarily placed with adult males alongside daggers, halberds, and various flint and ground stone weapons. This indicates that, upon entering the mortuary domain, axes underwent a profound change in their meaning, transitioning from woodworking tools to identity markers. While several scholars claim that the identities defined in the grave through metals would involve social elevation and political leadership, alternative interpretations are possible. In particular, this author argues that unusual life or death circumstances, perhaps marked by the trauma of suffered or inflicted violence, may explain why certain dead were left undisturbed in the grave, their metal and non-metal goods untouched for eternity. For many other dead, goods would be removed from the grave and re-circulated among the living during extended funerals, which involved the dismemberment and re-circulation of body parts. For yet other dead, metal objects may not have been employed in funerals at all but were perhaps kept by the living until the time came to melt them down and recycle the raw material.

If correct, this interpretation carries an important corollary: the axes that we see in the archaeological record represent merely the tip of an iceberg consisting of tens of thousands of mundane tools that must have concluded their social lives in a melting crucible. For nearly two centuries, archaeologists have studied the tip of this iceberg, neglecting the rest. They may now find it more rewarding to shift their attention to the submerged mass of metals that have become invisible due to widespread recycling. It is this author's contention that the study of these invisible metals will offer some of the ripest fruits that archaeometallurgists can hope to pick in the next few decades.

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Metal, networks, and social change in Central Europe and Southern Scandinavia (c. 4100–1700 BC)

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Zusammenfassung

Metall, Netzwerke und gesellschaftlicher Wandel in Mitteleuropa und Südskandinavien (ca. 4100–1700 v. Chr.)

In den vergangenen zehn Jahren haben Untersuchungen anhand von Bleiisotopenanalysen an mittel- und nordeuropäischen Kupfer- und Bronzeartefakten zu einer teils veränderten Rekonstruktion der europaweiten Austauschnetzwerke geführt. Ebenfalls liegen neue Nachweise früher Metallurgie vor. Dementsprechend werden sämtliche Kupferartefakte und -erze, die bis etwa 3350 v. Chr. in Mitteleuropa und Südskandinavien verwendet oder eingeführt wurden, südosteuropäischen Kupferquellen zugeschrieben, wohingegen die südmitteleuropäischen Kupferquellen hauptsächlich danach und die nordwesteuropäischen Ressourcen erst ab ca. 2200 v. Chr. ausgebeutet wurden (Brozio et al. 2023).

Die für ca. ab 3800 v. Chr. nachgewiesenen überregionalen Netzwerke und einheimische Kupferverarbeitung stehen mit sozialgeschichtlichen Transformationen im Zusammenhang. Einige Gemeinschaften lehnten die neue Technologie ab, andere nahmen sie an. Interessanterweise fällt der Beginn der einheimischen Kupfertechnologie in Mitteldeutschland mit der Errichtung der chalkolithischen Grabhügel für Einzelbestattungen ab ca. 3800 v. Chr. zusammen und die Einführung der Zinnbronzetechnologie mit dem Bau der großen frühbronzezeitlichen Hügel ab etwa 2000 v. Chr. Damit verbundene performative Architektur wird hier als Ausdruck sich ändernder sozialer Praktiken gedeutet.

Neue Untersuchungen am Schneiderberg in Baalberge, Salzlandkreis – namensgebend für die chalkolithischen Baalberge-Gesellschaften – haben ergeben, dass es sich um einen chalkolithischen Grabhügel handelt, der in der Frühbronzezeit von einem zweiten Hügel überdeckt wurde (Zolchow et al. in prep.). Die Biografie des Fundortes spiegelt offensichtlich die zwei Haupttransformationshorizonte der Einführung der Kupfer- bzw. Zinnbronzemetallurgie wider.

Schlagwörter Kupferverarbeitung, Neolithikum, Bronzezeit, Netzwerke, soziale Veränderungen

Summary

In the last ten years, studies with lead isotope analyses of Central and Northern European copper and bronze artefacts have led to a partially modified reconstruction of European-wide exchange networks. New evidence on early metallurgy has also emerged. Accordingly, the copper artefacts and ores used or introduced into Central Europe and Southern Scandinavia up to c. 3350 BC are attributed in their entirety to Southeastern European copper sources, whereas Southern-Central European copper sources are primarily exploited thereafter and Northwestern European resources are also utilised only from c. 2200 BC onwards (Brozio et al. 2023).

Supra-regional networks and indigenous copper processing documented from around 3800 BC are linked to sociohistorical transformations. Some societies rejected the new technology, others embraced it. Interestingly, the emergence of indigenous copper technology in Central Germany correlates with the construction of Chalcolithic burial mounds for individual burials from c. 3800 BC onwards and the introduction of tin bronze technology with the construction of Early Bronze Age large burial mounds from c. 2000 BC onwards. Corresponding performative architecture is interpreted here as an expression of changed social practices.

New investigations at the Schneiderberg of Baalberge, Salzlandkreis district, which gave its name to the Chalcolithic Baalberge societies, have shown that we have a Chalcolithic burial mound here, which was later covered over by a secondary mound again in the Early Bronze Age (Zolchow et al. in prep.). The biography of the site obviously represents the two main transformation horizons for the introduction of copper and tin bronze metallurgy.

Keywords copper metallurgy, Neolithic, Bronze Age, networks, social differentiation

Introduction

A key aspect of European prehistory is the question whether and in what form the introduction of copper or bronze metallurgy brought about changes in social practices[1]. To what extent can we assume that social consequences were associated with the introduction of these new technologies due to, for example, the need to organise processes based on the

1 Klassen 2003; Meller et al. 2014; Pernicka 2004; Strahm 2001.

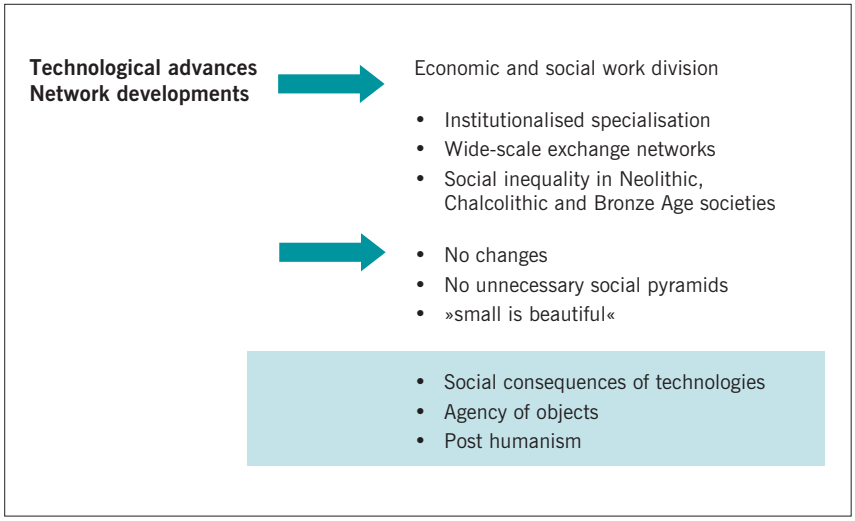


Fig. 1 Possible contrary consequences of technological innovation and network developments.

Abb. 1 *Mögliche gegensätzliche Folgen von technologischer Innovation und Netzwerkentwicklungen.*

division of labour or the maintenance of regional and supra-regional supply networks? The highly topical question is therefore whether technologies inherently cause social change without the actual actors being aware of it.

These »socio-technological aspects« of prehistoric technological innovations also relate to the question of the social consequences of technologies raised by T. Adorno (1966), among others, which is also reflected in the comments of I. Illich (1973) and L. Mumford (1967), who all emphasise the agency of technologies in the context of social or ecological issues.

In principle, the question is whether technological advances and network developments lead to economic and social work division with (1) institutionalised specialisation, (2) wide-scale exchange networks, and (3) social inequality in Neolithic, Chalcolithic, and Bronze Age societies, or whether (1) no changes, (2) no unnecessary social pyramids, and (3) »small is beautiful« are possible (Fig. 1).

Archaeologists have been discussing this for a long time. Both the extreme advances in metal analysis and in dating precision make it currently much easier to empirically evaluate archaeological sources with regard to the question of the relationship between technological innovations and social changes. Even if the interpretative approaches of those who attach great importance to metallurgical production for social development (Strahm 2010) and of those who tend to negate its importance (Bartelheim 2007) raise further questions, the relationship between the appearance of monuments for individuals and peaks in metalworking in Central Europe remains striking, in addition to differences in the acceptance of new prehistoric metal technologies.

In the following, we will therefore first present some new findings on copper technology, then introduce the question of the social consequences of the acceptance/rejection of technologies, and, finally, outline the consequences using the example of the Schneiderberg of Baalberge.

The changing picture of copper supply between the Black Sea and the North Sea

Recent metallurgical provenance studies based on lead isotope analyses show that metallurgical products were bartered from the Balkans to Central Europe and Southern Scandinavia both earlier and longer than originally assumed. As early as 2015, E. Pernicka and C. Frank, and later E. Pernicka, H. W. Norgaard, and H. Vandkilde, were able to prove that the so-called Mondsee copper did not originate from Eastern Alpine copper resources, but must have come from Balkan copper sources (Frank/Pernicka 2012; Pernicka/Frank 2015; Nørgaard et al. 2019). Another study, in particular on Bronze Age copper artefacts, also showed that metal artefacts from the Nordic Neolithic have corresponding signatures (Nørgaard et al. 2021).

Irrespective of these changing indications, the great importance of copper metallurgical developments in Southeastern Europe is beyond question due to their early appearance, to their possible socio-historical consequences, and to their influence on Central and Northern European development[2].

In a study that we recently presented, 45 Neolithic copper objects were newly investigated, representing the largest number of corresponding artefacts from the Northern Central European lowlands and from Southern Scandinavia thus far (Brozio et al. 2023). These analyses suggest that the origins of the Early Neolithic northern artefacts (c. 4100–3300 BC) are from the Serbian mining areas, whereas the Middle Neolithic artefacts (c. 3300–2800 BC) are from the Slovak Ore Mountains, the Eastern Alps, or the Serbian mining areas still in operation. Late Neolithic and Early Bronze Age artefacts (c. 2300–1700 BC) are also based on materials from the Slovak Ore Mountains and the Alpine region, after 2000 BC also from Wales.

2 Hansen et al. 2015; Klassen 2004; Radivojević/Roberts 2021; Radivojević/Rehren 2021; Rosenstock et al. 2016.

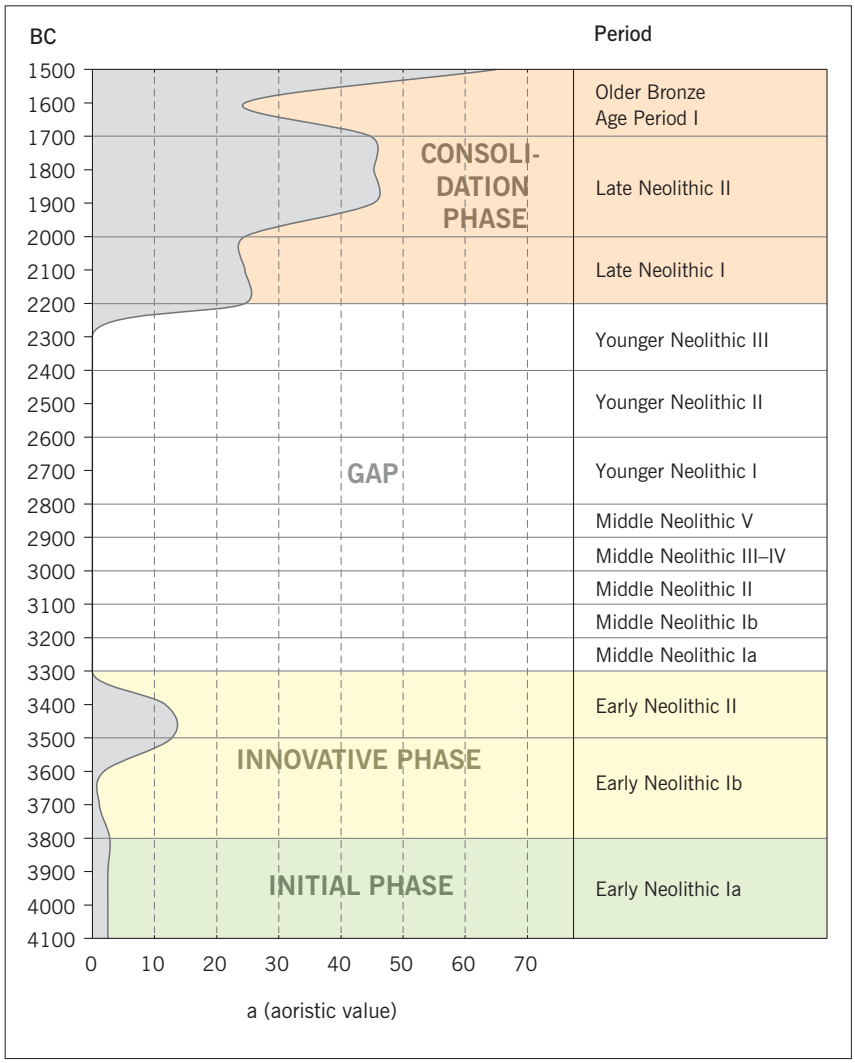


Fig. 2 Relative frequency (number of objects per century) of Neolithic copper objects in Northern Germany and Southern Scandinavia (cf. Brozio et al. 2023, 3 Fig. 3). The duration of the archaeological periods in Southern Scandinavia and Northern Central Europe are marked. The classification of metal use and production is also indicated. An initial phase with first copper item imports, an innovative phase with local metal processing, and a consolidation phase with an established metal production are marked. The »gap« describes a period with only very low indications of metal items.

Abb. 2 *Relative Häufigkeit (Anzahl der Objekte pro Jahrhundert) von neolithischen Kupferobjekten in Norddeutschland und Südskandinavien (vgl. Brozio et al. 2023, 3 Abb. 3). Die Dauer der archäologischen Perioden in Südskandinavien und Nordmitteleuropa ist angegeben, ebenso die Klassifizierung in Metallverwendung und -produktion. Eine Anfangsphase mit den ersten importierten Kupferobjekten, eine Innovationsphase mit lokaler Metallverarbeitung und eine Phase der Konsolidierung mit etablierter Metallherstellung sind gekennzeichnet. Die Lücke (»GAP«) stellt eine Zeit mit sehr wenigen Hinweisen auf Metallobjekte dar.*

Quantities and qualities of copper supply in the north

Based on various publications, there are clear periods of utilisation or deposition of copper artefacts in the Nordic region (Fig. 2). Both quantitatively and qualitatively, we can identify different phases of copper utilisation, as they have also been defined for other areas, e.g., Southern Central Europe, Southeastern Europe, or the Near East (first in Strahm 1994): an initial phase with the first metal objects, an innovative phase with independent local copper metallurgy, and a consolidation phase with established metal production. A gap, i.e., an interruption in development with only minor evidence of metal objects, can also be detected in the north, similar to Southern Central Europe.

The earliest objects probably appear from 4100 BC with the beginning of the Neolithisation of Southern Scandinavia and Northern Germany, while the first boom in copper artefacts occurs from around 3600 BC and especially in the Early Neolithic II (Fig. 3–4).

The oldest objects are a cross-edged axe of the Jászladány type and various hatchets, which were analysed for trace element concentrations. The probable origin of mining areas in Burgas, Bulgaria, and Belovode, Braničevo district and Majdanpek, Bor district (both Serbia) confirms the link to the core regions of South-eastern European technological development. Typochronologically, we find ourselves in Bulgaria in the area of Varna/KGK VI (Kodjadermen-Gumelnița-Karanovo VI) and Sălcuța/Krivodol, and in Serbia in the vicinity of Vinča D and Bubanj-Hum Ia. The main copper-processing societies of Southeastern Europe are therefore involved. For them a more stratified society is assumed, partly due to the depiction of relational power in the Varna cemetery or in Durankulak.

Social analyses of the Durankulak cemetery show that the increase in individual differences concerning access to resources led to increased inequality (Windler et al. 2012). While the tell settlement habitation practice was largely abandoned on the Lower and Middle Danube, the export of the first metal artefacts to the north was followed by the introduction of copper casting around c. 3800 BC also in Northern Central Europe. The appearance of the oldest copper artefacts in Northern Europe thus coincides with a period of considerable change both on the Lower and Middle Danube at the end of the settlement mound construction phase there and the transformation to agrarian production methods in Southern Scandinavia and Northern Central Europe.

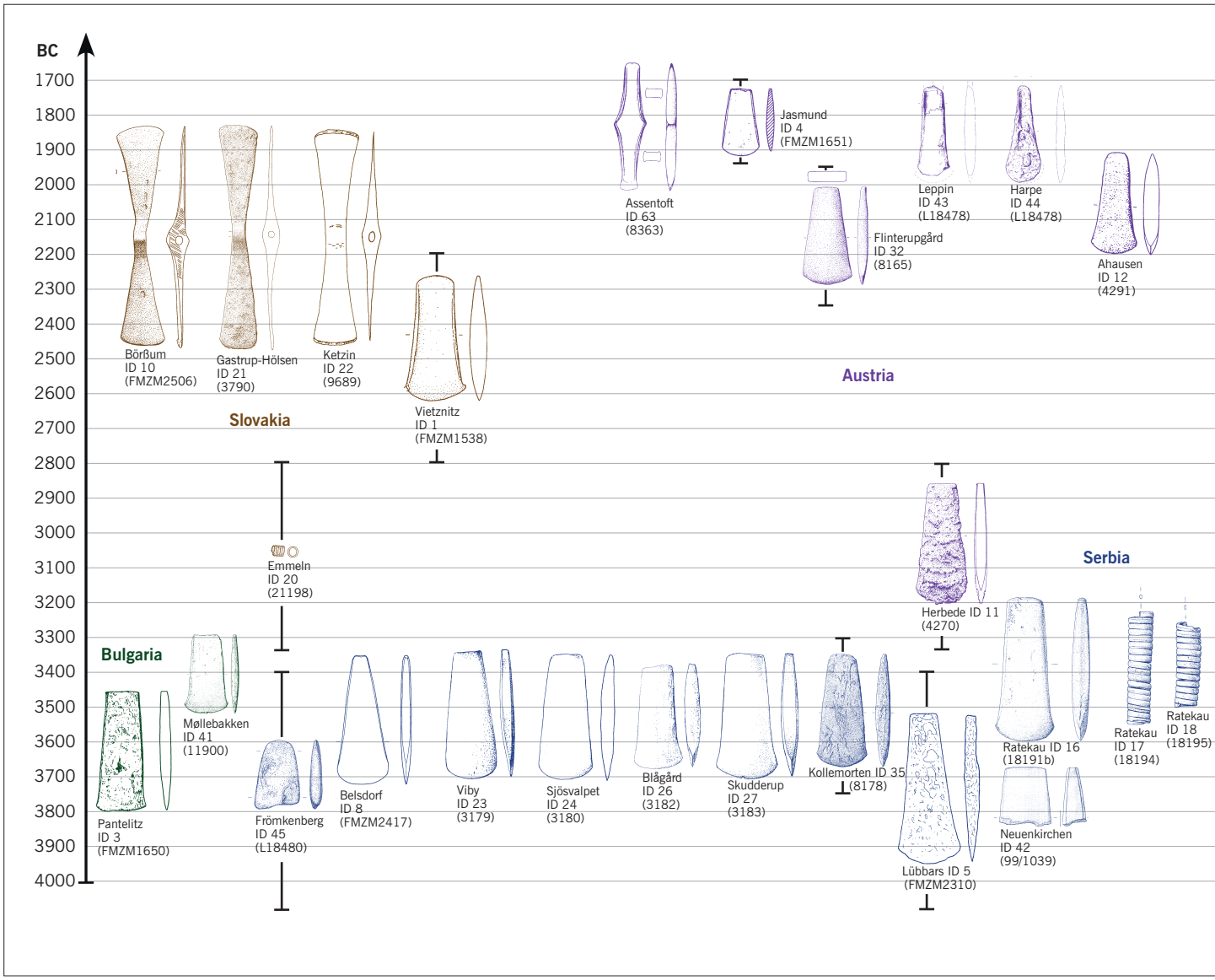


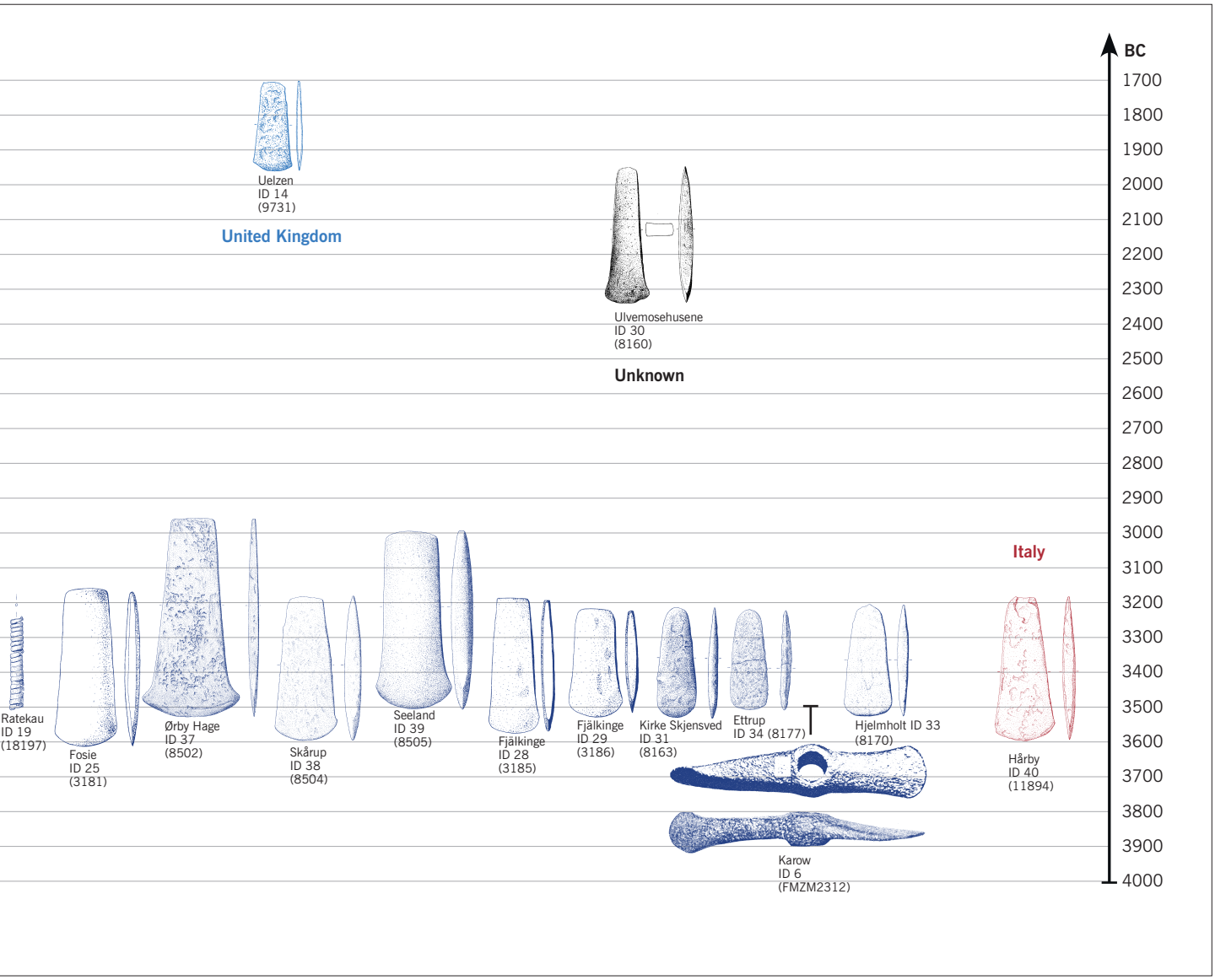
Fig. 3 Chart of the chronological sequence of the Neolithic copper artefacts and the origin of the raw material in the recent study (Brozio et al. 2023).

Abb. 3 *Chronologische Abfolge der neolithischen Kupferartefakte und der Herkunft des Rohmaterials aus der jüngsten Untersuchung (Brozio et al. 2023).*

There is direct evidence of the introduction of copper technology in the north from various sites. Here, a tuyère from the Funnel Beaker settlement of Kotowo, Wielkopolsky county (Central Western Poland; Żurkiewicz et al. 2023) probably comes from a metal workshop and radiometrically dates to the 39th or 38th century BC (cf. Skorna in this volume). In Lønt, Haderslev Municipality in Southern Jutland (Gebauer et al. 2021, 29–34), fragments of a crucible and a tuyère were also found under a long barrow with two dolmens in connection with pottery from the Early Neolithic Ib (3800–3650 BC). The investigations showed that the vessel came into contact with molten copper. Another indication of local metallurgical activity is the »deliberate fragmentation of copper flat axes by hot-shorting« – a method of reworking and possibly recycling copper objects (cf. Skorna in this volume). This technology was observed at the Neuenkirchen hoard and the Bygholm hoard (Skorna 2022).

Sociohistorically, we observe a change in the Funnel Beaker societies at this early time from around 3800 BC. For the first time, non-megalithic long barrows were erected for individuals, and human bones were deposited in Nordic bogs (Müller et al. 2014; Sörensen 2020). The extent to which this is a representation of social differences – as postulated by some – should be left open at this point. In any case, it is clear – with a more or less constant quantity of deposited copper objects – that objects produced by others initially appear as part of the exchange networks of the ear-

3 Of the objects analysed, a spiral from the depot find of Ratekau, Ostholstein district (Riesebusch; ID 17) could come from a Slovakian ore source. A flat axe from Tremmen, Havelland district (Brandenburg; ID 7) might come from Alpine raw materials, but it is chemically not consistent with ores from »Austria, North Tyrol«. The typochronological classification of the flat axe from Harby, Syddanmark, (ID 40) is unclear and will not be considered further here (cf. Brozio et al. 2023).



liest Funnel Beaker Cultures at the beginning of Neolithisation and, from around 3800 BC, copper metallurgy is also temporarily established at the same time as the appearance of the first superficially visible monuments.

The first boom in metal artefacts, which were evidently casted locally, began around 3600 BC and continued until around 3300 BC. The copper sources continued to be located in Southeastern Europe (Fig. 5). Two artefacts could indicate the beginning of the exploitation of Alpine sources[3]. This first boom in metal artefacts in the north was accompanied by considerable environmental and social transformations. Their economic expression can be found in the considerable clearances, which may be linked to the introduction of the plough and wagon (Müller 2019). Social and ritual practices were also changing: Numerous causewayed enclosures were now built. The Funnel Beaker communities seemed to organise themselves cooperatively, which is also reflected in their first megalithic tombs.

Subsequently, the deposition of metal objects and the utilisation of copper in the north came to a standstill from 3300 BC (cf. Klassen 2003; Brozio et al. 2023). In the western FBC, a spiral from Emmeln, Emsland district, and a flat axe from Herbede, Ennepe-Ruhr district, probably date to this period. According to the lead isotope analyses, these Middle Neolithic artefacts can be attributed to Southern Central European ore sources (of Slovakian and Austrian origin). Three Danish flat axes, which can be dated to around 3200 BC and whose raw material comes from Serbian sources, could certainly also date earlier (Brozio et al 2023).

Overall, we would associate the reduction in copper utilisation in the northern Middle Neolithic not only with the collapse of Southeastern European social relationships, but also with the changed social conditions in the Funnel Beaker communities. Since the exploitation of Slovakian copper sources is now obviously possible, the »copper emptiness« that now set in in the north can certainly be attributed to social network relationships. After the period of the dominance of passage graves as a collective burial practice and the establishment of the first village communities, the emphasis on the individual through individual graves began in many areas around 3100 BC at the latest. Here, other ways of displaying prestige or status probably became social practice – without metals playing a role. Even if isolated objects (e.g., the flat axe from Vietznitz, Havelland dis-

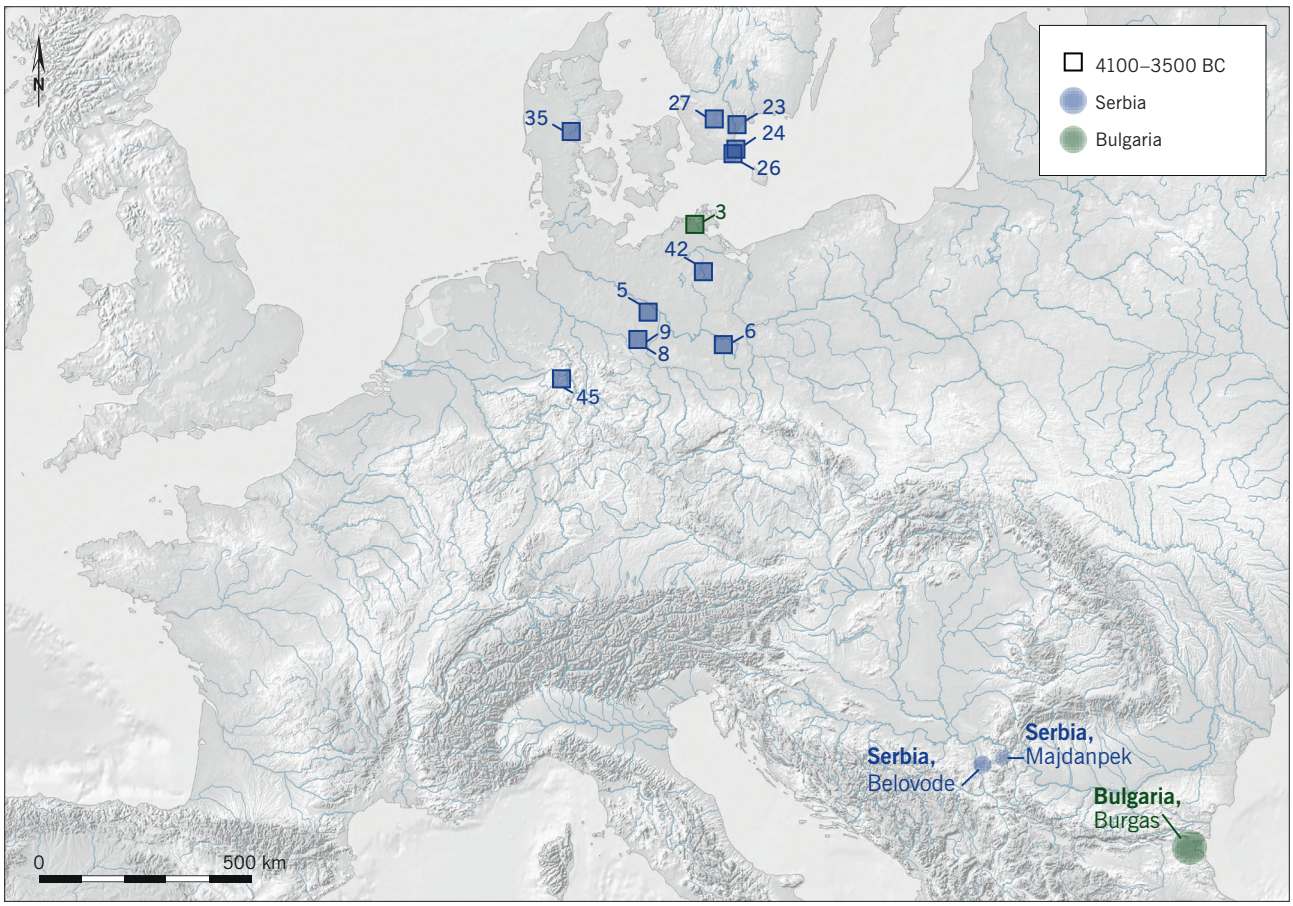


Fig. 4 Sites of the sampled objects (c. 4100–3500 BC) and the regions of origin of their copper based on the analyses of the recent study of copper items (cf. numbers in Brozio et al. 2023).

Abb. 4 *Fundorte der untersuchten Objekte (ca. 4100–3500 v. Chr.) und die Herkunftsregionen des Kupfers anhand der jüngsten Analysen (Nummern vgl. Brozio et al. 2023).*

trict, ID1 in Brandenburg) can be dated to the following period, this absence of metal continues until around 2300 BC in the period under consideration.

From around 2300 BC, Zabitz axes made of Slovakian ore are found in southern regions of Northern Germany, whereas, from 2200 BC at the latest, numerous flat axes from Alpine copper sources, but also individual examples from North Wales, likewise found here. The now developing quantitative peak in the Nordic Late Neolithic and the Nordic Early Bronze Age certainly reflects the changed social conditions. The production of metal objects increasingly became the basis of exchange systems.

Economic and social interpretation in the north: Cooperative societies against copper?

Overall, it becomes clear, especially in comparison with the economic and social development, that copper metallurgy in the north only rarely played a role in which the necessities of technological development brought about social changes. The discovery and use of the first copper objects before 3800 BC (as in other regions) are linked to general exchange relations at the time of the initial Neolithisation. The use of a »small technology« with its own small copper metallurgical workshops in settlements from around 3800 BC can possibly be linked to social differentiation processes, which some scholars recognise in the non-megalithic long barrows (Sörensen 2020). Interestingly, this increase in regional copper metallurgical products breaks off at a time when more cooperative social relationships can be recognised in the Middle Funnel Beaker societies. Thus, the megalithic boom parallels a metallurgical bust (Fig. 6): Elements other than ›copper‹ come to the fore in the communal shaping of the new agricultural cultural landscape. The minor importance of metallurgical production leads to the abandonment of corresponding references in this phase. Obviously, cooperative societies are active in other technological environments.

A corresponding socioarchaeological context has already been discussed in relation to the distribution of early metal daggers in Central and Northern Germany (Müller 2012; Müller 2013). It was argued that metal daggers were known and occasionally worn in Northern Germany around 3800/3700 BC, but, in contrast to Southern Central Europe, they did not establish a ›dagger tradition‹ for purposes of social representation – neither in metal nor flint. This was labelled a ›missed innovation‹ (Fig. 7).

This results in the following model for Northern Germany and Southern Scandinavia:

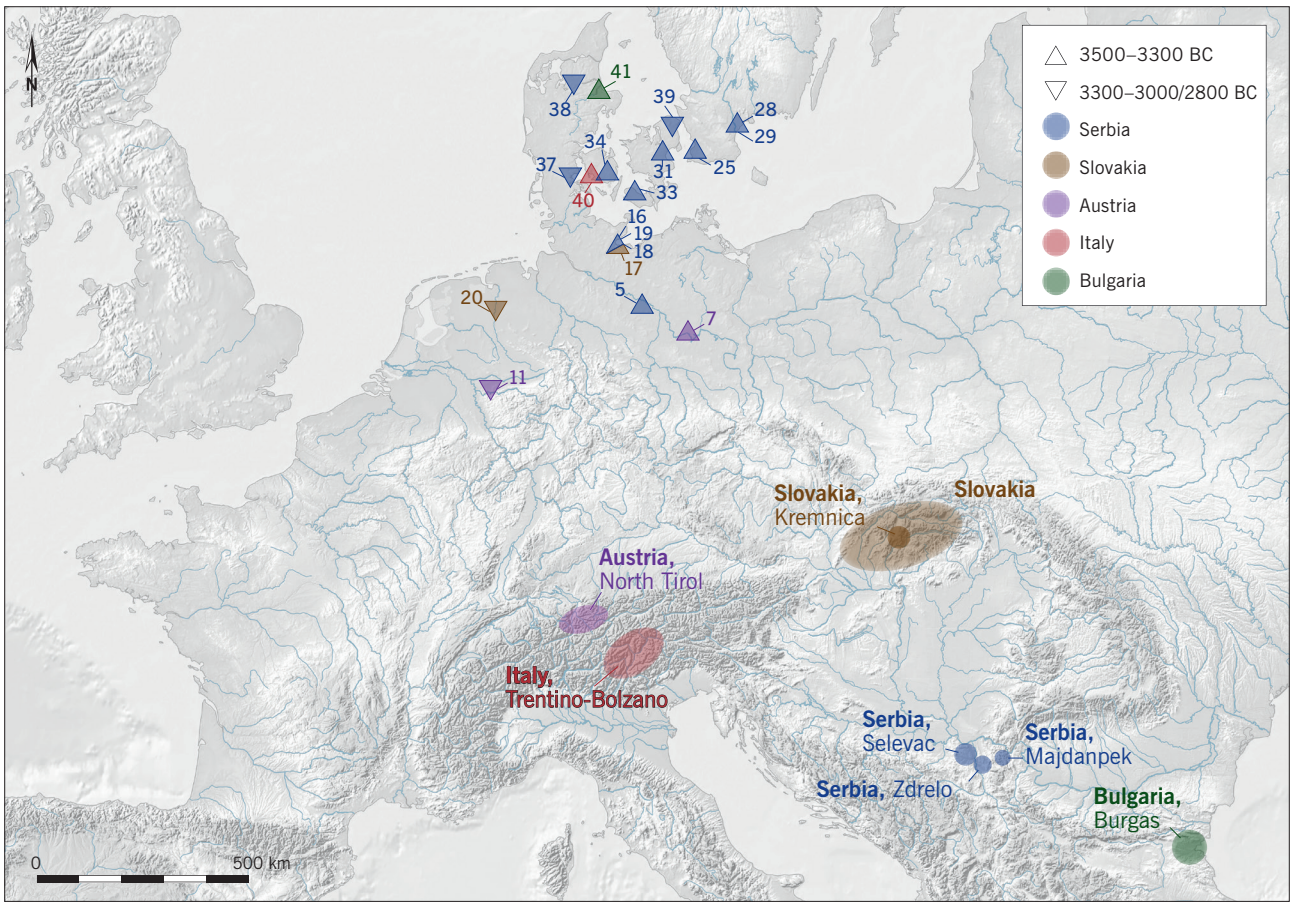


Fig. 5 Sites of the sampled objects (c. 3500–3300 BC and 3300–3000/2800 BC) and the regions of origin of their copper based on the analyses of the recent study of copper items (cf. numbers in Brozio et al. 2023).

Abb. 5 *Fundorte der untersuchten Objekte (ca. 3500–3300 v. Chr. und 3300–300/2800 v. Chr.) und die Herkunftsregionen des Kupfers anhand der jüngsten Analysen (Nummern vgl. Brozio et al. 2023).*

1 The introduction of copper usage and casting remained small-scale and without any social consequences. This becomes visible, e.g., in the small flow of imports until c. 3300 BC, in the small number of locally casted copper items, and in the rejection of a prestige value for metal objects.

2 Even if a ›metallic gap‹ with only low numbers of metal objects was postulated for other areas of Central Europe,

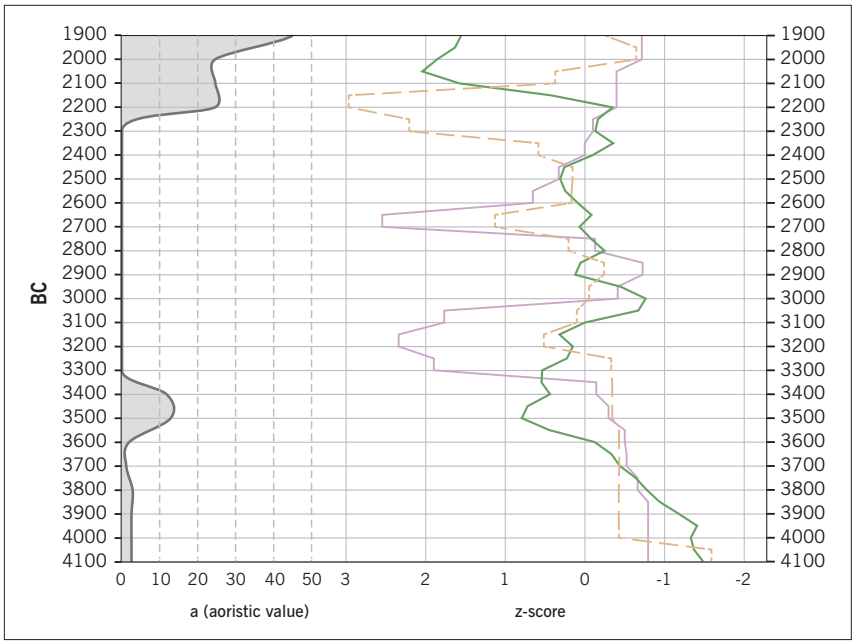


Fig. 6 A comparison of the relative frequency of metal objects and economic and social practices in northern Germany and southern Scandinavia. The latter were calculated based on palynological data and relative frequencies of architecture and depositions in Northern Germany. Green: land opening; purple: monuments; light brown: deposition of prestige goods (cf. Fig. 2 and study of Brozio et al. 2019).

Abb. 6 *Vergleich der relativen Häufigkeit von Metallobjekten sowie wirtschaftlichen und sozialen Praktiken in Norddeutschland und Südskandinavien. Letztere wurden anhand von pollenkundlichen Daten und der relativen Häufigkeit von Architektur und Niederlegungen in Norddeutschland bestimmt. Grün: Abholzung; lila: Monumente; hellbraun: Niederlegungen von Prestigeobjekten (vgl. Abb. 2 und Analysen von Brozio et al. 2019).*

Abb. 7 The dagger of Aspenstedt (length 11.8 cm). While the early copper daggers in Southern Germany were triggering the adaptation of ›daggers‹ as a social symbol within societies, in the ›north‹ this was not the case. Early copper daggers, like this one from Aspenstedt, remain an exception.

Fig. 7 *Dolch von Aspenstedt (Länge 11,8 cm). Während die frühen Kupferdolche in Süddeutschland zur Übernahme von »Dolchen« als sozialem Symbol führten, war dies im »Norden« nicht der Fall. Frühe Kupferdolche wie der von Aspenstedt bleiben eine Ausnahme.*

the gap seems especially more extreme and long-lasting in the ›north‹.

3 The consolidation of metal production as a primary technology for producing utilitarian and non-utilitarian items takes place simultaneously with the economic changes in the Nordic Late Neolithic.

This development is very different from what we know from Central Germany and Greater Poland.

Economic and social development in Central Germany

In contrast to the cooperative societies of the north, we have long been familiar with the debate surrounding the social interpretation of the legacies from the Chalcolithic and Early Bronze Age of Central Germany and Greater Poland[4]. On the one hand, the introduction of copper metallurgy from c. 3800 BC is associated with considerable differentiation in the burial system (including the construction of round and long mounds for individual burials) and a boom in large causewayed enclosures (Klassen 2014; Schwarz 2003). On the other hand, the large burial mounds of the Early Bronze Age Únětice Group, in particular, are an expression of increased hierarchisation in connection with the consolidation of tin bronze technology (Bertemes 2010; Bertemes 2016; Steffen 2010). While the extraordinary development in the introduction of copper metallurgy initially appears to be limited to the Central German region, the social developments in the introduction of tin bronze technology between Central Germany and Greater Poland can certainly be considered parallel (e.g., Czebreszuk et al. in print; Müller et al. 2023).

In fact, the appearance of the oldest round barrows for individual burials in Central Europe in the Central German Baalberge area is probably linked to economic changes that caused increased social differentiation within society (Müller 2001). These economic changes included the introduction of copper metallurgy as well as changes in the subsistence sector.

In contrast to the Baalberge burial mounds, the Únětice burial mounds provide evidence that the control over metallurgical processes was obviously exercised by the individuals buried there (Bertemes 2016).

The two phases of greater social differentiation in Central Germany, which may also be linked to the role of metallurgy, are paradigmatically illustrated by the Baalberge-Schneiderberg burial mound. The site, which gave its name to the Baalberge societies, contains the various prehistoric remains known since the old excavation. Geophysical investigations and dating of drilled sediments from the burial mound have now shown that it is comprised of a two-phase burial mound fill (Müller et al. in prep.) – first, a 1.5–2.0 m high Baalbergian primary mound, which was subsequently covered over by a 3.0–3.5 m high secondary burial mound in the Early Bronze Age for the rich Early Bronze Age ceremonial burial (Fig. 8).

Conclusion

The brief reference to new lead isotope analyses and the comparison of the results with some social developments have confirmed certain ideas about the role of metallurgy for the early copper-using societies of the north, while refuting others.

4 Czebreszuk 2013; Meller et al. 2016; Müller 2001; Münster et al. 2018.

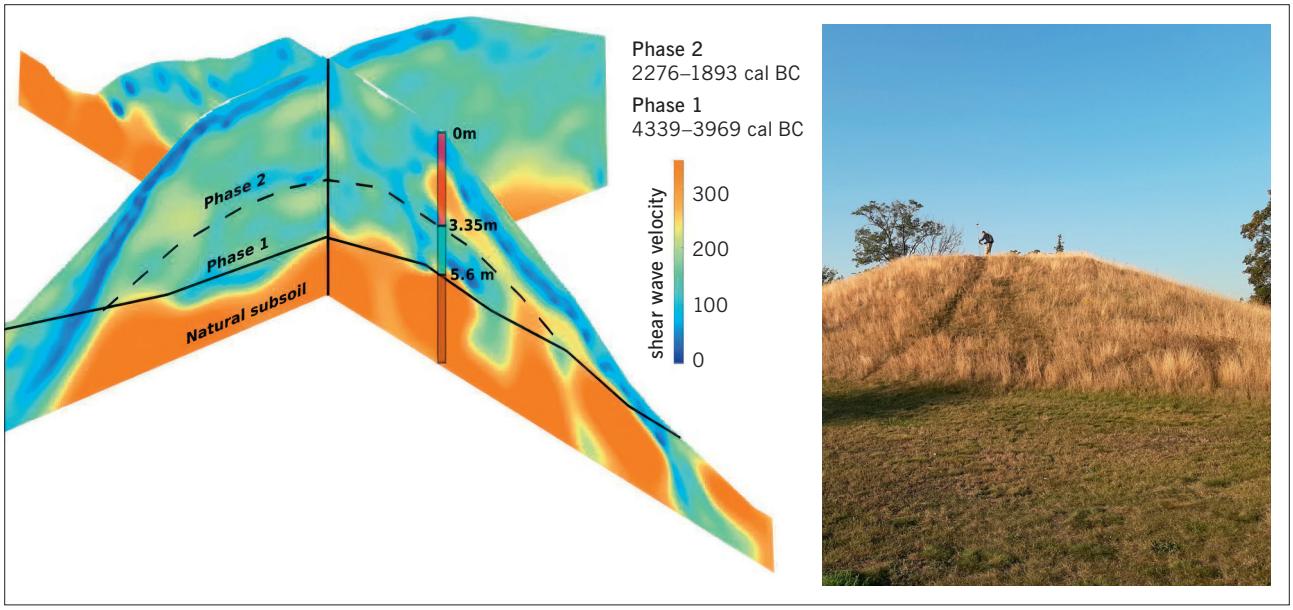


Abb. 8 Schneiderberg, Baalberge, Salzlandkreis district (Saxony-Anhalt). With different geophysical methods, two phases of the mound have been detected. Phase 1 (height 1.80 m) is associated with the Baalberge cist; phase 2 (additional 3.35 m height) with the EBA burial. Based on ^{14}C-dating of material from drillings, phase 1 filling material is dated to soil from 4340–3970 cal BC; phase 2 filling material to soil from 2275–1890 cal BC (Müller et al. in prep.).

Fig. 8 *Schneiderberg, Baalberge, Salzlandkreis (Sachsen-Anhalt). Mithilfe verschiedener geophysikalischer Methoden konnten zwei Phasen des Hügels ermittelt werden. Phase 1 (Höhe 1,80 m) wird mit dem Baalberge-Steinkistengrab in Zusammenhang gebracht; Phase 2 (weitere 3,35 m Höhe) mit der frühbronzezeitlichen Bestattung. ^{14}C-Daten von Bohrungen haben ergeben, dass das Aufschüttungsmaterial von Phase 1 auf 4340–3970 cal BC datiert, von Phase 2 auf 2275–1890 cal BC (Müller et al. in prep.).*

While local metallurgical processing techniques were already present, the role and meaning of copper artefacts was not the trigger of a social transformation of the northern societies.

The first integration of copper metallurgy and the use of copper objects in Neolithic societies in Northern Central Europe and Southern Scandinavia was part of a wider development of transformation processes in the 4th millennium BC, including:

- communication and exchange networks
- changes in the subsistence economy
- new technologies, such as the introduction of the animal drawn plough or the wheel and wagon.

The early consolidation of copper metallurgy was not a sustainable process, perhaps rejected by cooperative societies. Only Nordic Late Neolithic and Early Bronze Age societies integrated copper metallurgy in such a way into their economic system that these metallurgical societies reached a point of no return with respect to metallurgy:

- increasingly using more metal artefacts as tools in the subsistence economy
- and for the display of power structures.

In contrast to Northern Europe, metallurgical input took place in Central Germany already at 3800 BC. Here, power structures were displayed in the earliest burial mounds of Central Europe for single individuals and in the Early Bronze Age mounds. Beside the well-known examples from Bornhöck, Saalekreis district, Helmsdorf, Mansfeld-Südharz district, and Leubingen, Sömmerda district, a fourth example is now known with Baalberge-Schneiderberg, where mound-building activities could be associated with the Central German Únětice Group.

Despite or precisely because of the results presented, we can in no way identify a socio-technological consequence of early metallurgy. Rather, the role of the new production technology remains embedded in the general economic and social development, which results from an interplay of different components of social transformation or stability.

Acknowledgements

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Source of figures

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Make and break: Intentional fragmentation of copper flat axes as evidence for metallurgy in the Northern Group of the Early Neolithic Funnel Beaker societies

Henry Skorna

Zusammenfassung

Vom Erschaffen und Zerstören. Intentionale Fragmentierung von kupfernen Flachbeilen als Nachweis von Metallurgie in der Nordgruppe der frühneolithischen Trichterbechergesellschaften

Dieser Beitrag betrachtet das Vorhandensein metallurgischer Aktivitäten in der Nordgruppe der frühneolithischen Trichterbechergesellschaften anhand der Untersuchung der intentionalen Fragmentierung von kupfernen Flachbeilen. Er prüft bekannte sowie neue Belege einer eigenständigen Kupfermetallurgie im westlichen Ostseeraum und beleuchtet das bisher unbeachtete Schadbild der Warmbrüchigkeit als Nachweis für metallurgisches Wissen in der Nordgruppe der Trichterbechergesellschaften. Vorgestellt werden drei Beispiele von Flachbeilen aus Neuenkirchen, Lkr. Mecklenburgische Seenplatte, Lackalända, Skåne (Schweden), und Nadrensee, Lkr. Vorpommern-Greifswald, mit solchen Warmbrüchen. Sie ermöglichen Einblicke in intentionale Zerstörungspraktiken und deuten auf die Anwesenheit von Metallurgen mit Kenntnissen in Pyrotechnologie hin. Die langdiskutierte Theorie von der »kleinen« Kupferzeit im westlichen Ostseeraum wird von der intentionalen Fragmentierung kupferner Flachbeile mittels Warmbrüchigkeit gestützt. Dieser Nachweis spricht zusammen mit den metallurgischen Werkzeugen aus Lønt, Haderslev Kommune (Dänemark), und Kotowo, Woi. Großpolen (Polen), für eine eigenständige Produktion von Kupferobjekten im Frühneolithikum (4100/4000–3300 v. Chr.), was bisherige Chronologien infrage stellt und die Bedeutung Mecklenburg-Vorpommerns für den Transfer metallurgischen Wissens zwischen den Trichterbechergesellschaften unterstreicht.

Schlagwörter Kupfer, frühe Metallurgie, Trichterbecher, Warmbrüchigkeit

Summary

This paper explores the presence of metallurgical activities in the Northern Group of the Early Neolithic Funnel Beaker societies through an examination of the intentional fragmentation of copper flat axes. It reviews the existing and latest evidence for an independent copper metallurgy in the Western Baltic region and introduces the hitherto unnoticed damage pattern of hot-shorting as evidence for the metallurgical knowledge in the Funnel Beaker societies of the Northern Group. Three examples of flat axes that were subjected to hot-shorting are presented here; originating from Neuenkirchen, Mecklenburgische Seenplatte district, Lackalända, Scania (Sweden), and Nadrensee, Vorpommern-Greifswald district, they provide insight into intentional destruction practices and indicate the presence of metalworkers with knowledge of pyro-technology. The long-discussed existence of a »little« Copper Age in the Western Baltic region is supported by the intentional fragmentation of copper flat axes through hot-shorting. This evidence, coupled with metallurgical tools from Lønt, Haderslev Municipality (Denmark), and Kotowo, Greater Poland Voivodeship (Poland), suggests an independent production of copper objects during the Early Neolithic (4100/4000–3300 BC), challenging previous timelines and emphasizing the significance of Mecklenburg-Western Pomerania as a gateway for the transfer of metallurgical knowledge between Funnel Beaker societies.

Keywords copper, early metallurgy, funnel beaker, hot-shorting

Introduction

At the turn from the 6th to 5th millennia BC in parts of Europe, a Copper Age can be proposed that is defined by mining, smelting, and casting[1]. From the early innovation centres in South-Eastern Europe, objects made of copper reach the Early Neolithic societies in Northern Germany and Southern Scandinavia roughly at the same time as the switch from a mobile to a sedentary lifestyle. While the initial numbers were rather low, one can observe a strong

1 See, amongst others, Rosenstock et al. 2016, 106. The project is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 290391021 – SFB 1266.

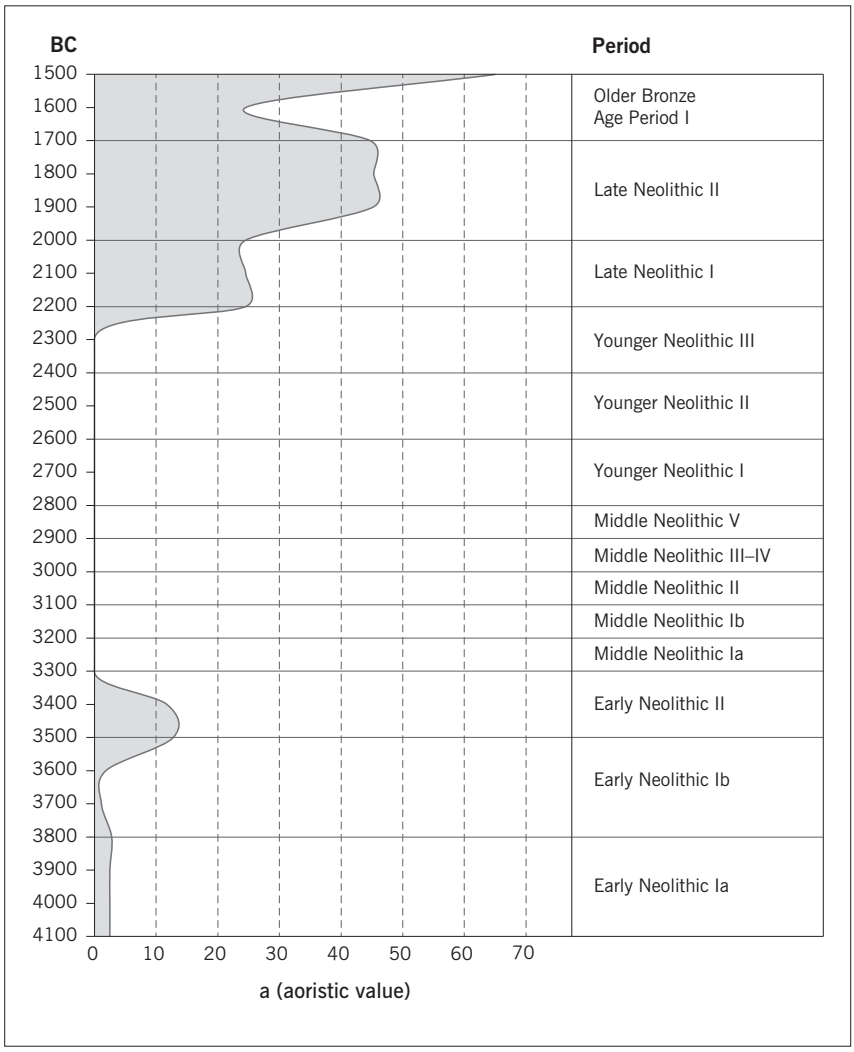

Fig. 1 Relative frequency of Neolithic copper objects in Northern Germany and Southern Scandinavia.

Abb. 1 *Relative Häufigkeit neolithischer Kupferobjekte in Norddeutschland und Südskandinavien.*

increase in copper artefacts starting around the beginning of the 2nd half of the 4th millennium (Fig. 1). The dominant object form in that isolated stage of Early Neolithic copper finds are flat axes. Limited numbers of daggers, arm spirals, hammer axes, and sheet-metal jewellery are also known. These objects are predominantly single depositions or single finds, although a number of multi-object depositions – such as the hoard finds from Bygholm, Horsens Kommune (Denmark), Neuenkirchen, Mecklenburgische Seenplatte district, and Riesebusch, Ostholstein district, – are also known (Fig. 2). Just as suddenly as it appeared, this increase in copper finds nearly completely vanished from the material culture at 3300 BC for the next 1000 years in the Western Baltic region. It is only in the Late Neolithic and Early Bronze Age that metal re-emerges (starting roughly at 2300 BC) and metallurgy is integrated permanently into the societies (Fig. 1). Whether this spike in numbers of Neolithic copper finds is due to an increased import of final products or the result of local production could not be ultimately determined. In very recent years, new discoveries are making the latter scenario more likely, and one could at least discuss the possibility of a »little« Copper Age in parts of Northern Europe. This paper summarises the available evidence and introduces further indications for the independent production of copper objects.

The question of an independent metallurgy in the Funnel Beaker North Group

In his comprehensive study of the copper finds of the Funnel Beaker North Group, L. Klassen (2000, 235–236) identified three main phases of metal use. The first phase (around 4000–3800/3700 BC) is primarily characterised by imports. In the 2nd phase (3800/3700–3500 BC), there is additional evidence of locally produced sheet-metal jewellery, and the mechanical treatment of objects forms part of the archaeological record. In the 3rd phase (3500–3300 BC), the archaeological evidence reveals the extensive mechanical and pyrotechnical treatment of objects as well as a wider variety of local types of flat axes and sheet-metal jewellery. Klassen (2000, 235–236) proposed that local, independent mining, smelting, and the production of copper objects took place in the Northern Group of the Funnel Beaker societies. This assumption is based on two major aspects:

Typological forms unique to the Funnel Beaker North Group. Klassen (2000, 233) identifies 13 different types that are specific to the Western Baltic region (Viborg, Ettrup, Pilegård, Riesebusch, Kieholm, Hyrup, Søby Hede, Avnslev, Vesterkobbel, Kerteminde, Lackalänga, Fosie, and Nosaby). Also striking is that, even if there are typological equivalents in, for example, the northern Alpine region, the

Fig. 2 The Neuenkirchen hoard, Mecklenburgische Seenplatte district, with the hot-shorted flat axe; no scale.

Abb. 2 *Hortfund von Neuenkirchen, Lkr. Mecklenburgische Seenplatte, mit dem warmbrüchigen Flachbeil; o. M.*

examples from the Funnel Beaker North Group are significantly (up to 2.5 times) bigger and heavier. For example, the known representatives of the ›Ettrup‹ type are nearly two times bigger and four times heavier than their typological equivalent of the northern Alpine form-type ›Maurach‹ (Klassen 2000, 164).

A copper variety (Riesebusch) that is only prevalent in the Western Baltic region. The specific composition with dominant trace elements of arsenic followed by antimony as the only significant admixture, along with local distribution as well as the local forms, leads Klassen (2000, 212–213) to the conclusion that exploitation of middle Swedish ore sources is a likely possibility. This has not yet been confirmed by lead isotopes, though. On the contrary, the latest study by J. P. Brozio et al. (2023) showed that most of this arsenic copper originated from South-Eastern European sources such as the east Serbian mine at Madjanpek, Bor district. More striking, the flat axe and one band spiral from the eponymous hoard find for the copper variety Riesebusch (Ratekau, Ostholstein district) show a lead isotope signature consistent with Serbian ore sources; and two others, which are also part of Klassen's (2000) analysis group VIII (Riesebusch copper), match the lead isotope ratios from the eastern Slovakian Kremnica region (Brozio et al. 2023, 9). The rising number of lead isotope analyses also hints towards a South-Eastern European origin of the so-called Mondsee copper variety[2]. This arsenic-rich copper, named after the metallurgy centre and archaeological culture at the eponymous lake Mondsee in Austria, has long been suspected to be from relatively close sources in the eastern Alpine region (Klassen/Stürüp 2001, 55–56). This was already controversially discussed by, e.g., C. Frank and E. Pernicka (2012, 131). More recent studies by J. P. Brozio et al. (2023), H. Skorna (2022), and H. Nørgaard et al. (2021) show that the lead isotope ratio of copper objects with this specific trace element composition are also consistent with sources from Serbia as well as Bulgaria. Thus, the overwhelming majority of the analysed copper dating between 3800 and 3300 BC in the Western Baltic originated from South-Eastern European sources.

Although new lead isotope data does not support a Swedish origin for the Riesebusch copper, and therefore independent ore mining and smelting is highly unlikely, the variety of local forms still speaks for a local pyrotechnical production of copper objects in the Northern Group of the Funnel Beaker societies. As Frank and Pernicka (2012) already pointed out, the relatively higher arsenic content is likely the result of the introduction of a new technology in form of an intentional addition of arsenic into the copper using speiss (Rehren et al. 2012, 1717–1718; Nørgaard et al. 2021, 10). Objects made of this copper from South-Eastern European sources could then have travelled from or via the Mondsee Culture in Austria to the Western Baltic region early in the Funnel Beaker period (Nørgaard et al. 2021, 10) and were then (partially) recast/reworked into the local forms.

Evidence for metallurgy

Numerous discoveries revealing metallurgical activities are known from the material culture of the younger Neolithic societies in the northern Alpine region (Matuschik 1998, find list A). From the lakeside settlements at Mondsee and Atternsee alone, more than 160 metallurgical tools are known (Matuschik 1998; Klassen 2000, 283). These include finds such as crucibles, tuyères, casting residues, slags, and moulds. To a lesser extent, such evidence is known for the South, East, and South-Eastern Group of the Funnel Beaker societies (Klassen 2000, 284–285; Gebauer et al. 2021; Żurkiewicz et al. 2023). In contrast to this, the evidence in the Northern Group of the Funnel Beaker societies was absent until very recently. In the following, this evidence is compiled and complemented with new examples.

2 Analysis of group VII after Klassen (2000).

Metallurgical tools from Lønt, Haderslev Municipality (Denmark)

The first hard evidence for metallurgy originates from the Danish site of Lønt. The site is a megalithic cemetery with eleven tombs and two causewayed enclosures (Gebauer et al. 2021, 29). Below a long barrow with two round dolmens from the early Middle Neolithic period I (around 3300–3100 BC), a Neolithic surface was preserved upon which fragments of a crucible and a tuyère were found. The pottery found in connection with both these objects can be dated to the Early Neolithic Ib (3800–3650 BC). An examination using scanning electron microscopy with energy dispersive analysis as well as with a µ-X-Ray-fluorescence scanner proved that the crucible had come into contact with molten copper (Gebauer et al. 2021, 32–33). Interestingly, the observed profile of the copper with predominant trace elements of arsenic and small amounts of nickel does not match the arsenic copper used to produce copper objects in the Northern Group of the Funnel Beaker societies within the Early Neolithic period. These objects made from this specific copper mostly also contain traces of antimony, silver, and small amounts of nickel in addition to the predominant trace element of arsenic.

Metallurgical tool from Kotowo, Greater Poland Voivodeship (Poland)

Due to the very close vicinity to other evidence from Nadrensee and Neuenkirchen (see below), the tuyère of Kotowo is included here as evidence for metallurgy, although, technically, the site belongs to the Eastern Group of the Funnel Beaker societies. The tuyère was found in a settlement feature with other pottery belonging to the earliest developmental phase of the Eastern Group of the Funnel Beaker societies (Żurkiewicz et al. 2023). Energy-dispersive X-ray fluorescence spectroscopy performed on the inner surface of the tuyère showed considerable traces of copper, proving that the object was directly involved in metal working (Żurkiewicz et al. 2023, 424–425).

From the feature, which was at least temporarily used as a metal workshop, several samples for radiocarbon dating were obtained. The combined dates place the workshop activity in a time bracket between 3911–3714 cal BC (68.5 % probability; 3942–3708 cal BC, 95 % probability; Żurkiewicz et al. 2023, 423–424). These are not only the oldest dates for a Funnel Beaker community of the first developmental phase of the Funnel Beaker societies – the Eastern Group in Greater Poland (Żurkiewicz 2023, 11) – but also the oldest evidence of advanced metallurgy in close vicinity to the Northern Group of the Funnel Beaker societies. This hints towards an influx of the metalworking technology into the Funnel Beaker communities via the Lengyel-Polgár Circle (Żurkiewicz et al. 2023, 430).

Hot-shorting as evidence for metallurgical activities

In addition to the hard evidence in the form of metallurgical equipment from Lønt and Kotowo, a specific damage pattern called »hot-shorting,« introduced here, is interpreted as proof of metallurgical activity. From the copper object inventory of the Funnel Beaker North Group, a number of damaged objects can be observed. Although damage also occurs in other object types[3], it is best observable in flat axes, which are generally better preserved due to their massiveness. For nearly 14 % of the 118 known pieces, different damage patterns such as bending, weakening of the structural integrity of the axe body, and blows against the neck have been documented (Fig. 3; Klassen 2000, 278–279). Other examples are known from the band spiral, sheet-metal fragment, and the

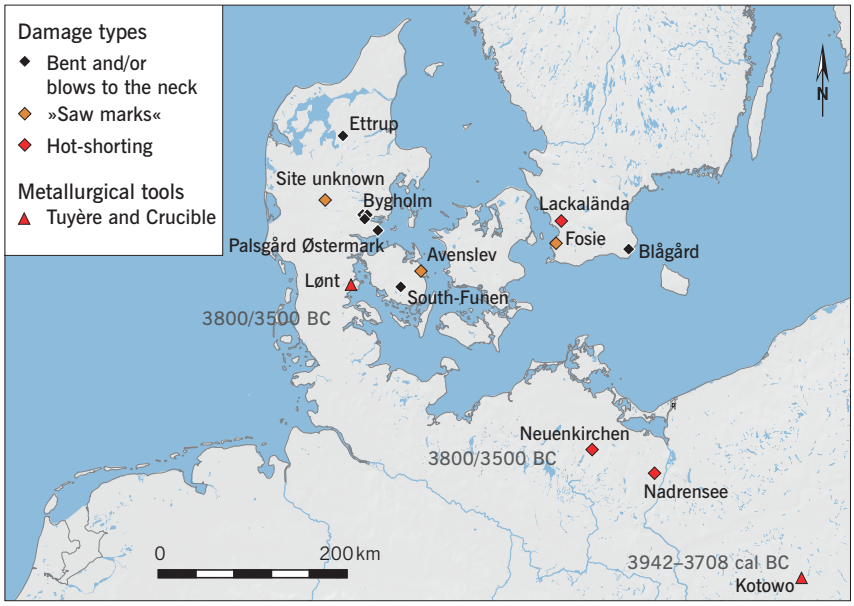

Fig. 3 Damage types observed on flat axes of the Funnel Beaker societies (Northern Group) and sites with evidence of metallurgy.

Abb. 3 *Schadensarten an Flachbeilen der Trichterbechergesellschaften (Nordgruppe) und Fundorte mit Nachweisen von Metallurgie.*

3 E.g., daggers or band spirals; Skorna 2022, 57.

dagger of Neuenkirchen (Skorna 2022, 53–54), but also from the dagger of Bygholm (Klassen 2000, Pl. 94F).

Although these damage types have already been described in the existing literature[4], a unique and specific type of damage has remained unnoticed in relation to the inventory of copper objects from the Funnel Beaker societies of the Northern Group: the so-called hot-shorting. Hot-shorting, also known as *»Warmbrüchigkeit«* in German, refers to a phenomenon observed in copper(-alloy) objects when they are heated beyond a specific temperature (usually up to 600–700 °C, and higher in the case of bronze). This extreme heat generates significant thermal stress within the material, causing it to fracture even under minimal pressure[5]. Depending on the temperature, even a slight touch leads to separation into pieces with no or only marginal deformation or further fragmentation (Knight 2019, 252). This can be caused by several elements which are either added to improve the workability or the general properties of the copper(-alloy). For example, in the British Late Bronze Age, the bronze is alloyed with tin and lead (Knight 2019, 252; Knight 2022, 16). As the segregated lead has a lower melting point than the copper/tin alloy, it increases the chance of a fracture when (over-)heated and worked. Certain other elements can also increase the likelihood of fractures. These elements do not have to be necessarily deliberately added during the production but can also be already present in the mined ore. Already 0.005 % bismuth can result in hot-shorting, as the melting of the bismuth along grain boundaries destroys the internal structure of the copper (Stahl 1925, 421–422; Dies 1967, 676; Junk 2003, 29–30). Moreover, antimony is known to cause brittleness and red-fracture (breaking when red-hot). Copper with an antimony level of 1 % is also reported to be extremely prone to hot-shorting. K. Dies (1967, 676) even calls it a harmful element to copper and copper alloys. While certain trace elements increase the likelihood of an axe hot-shorting, the main reason is that the work piece is being annealed too intensely or worked in a red-hot state (Kuijpers 2018, 122). This is usually considered to be a mistake made by an inexperienced metal worker (Kuijpers 2018, 220; 232). More importantly, deliberately destroyed objects exploiting the hot-shorting of copper(-alloys) are also known. M. Kuijpers (2018) lists several examples of the Early Bronze Age and the Copper Age, with one example being possibly hot-shorted deliberately (Axe 329, Kuijpers 2018, 181). M. G. Knight (2022, 66; 105) lists several examples of deliberately hot-shorted objects originating from Late Bronze Age depositions in southern Britain. So far, most of the cases are known from the Bronze Age. This is probably due to the smaller number of early copper objects but also to a research desideratum. In general, the number of hot-shorted objects seems to be rather low, but the damage pattern may also have been overlooked or not recognised, as in the case of the Northern Group Funnel Beaker societies and probably also in the remaining Funnel Beaker groups.

Hot-shorting examples in the Northern Group of the Funnel Beaker societies

As shown above, the access to metallurgical knowledge can be evaluated using damage analysis, which can confirm the presence of hot-shorting. In the following, three examples of hot-shorted flat axes are described (Fig. 3).

Neuenkirchen, Mecklenburgische Seenplatte district

The flat axe of Neuenkirchen is part of an ensemble of five copper objects found during construction work. The hoard consists of a dagger, a large arm spiral, a band spiral, a sheet-metal fragment probably belonging to a pendant, and the aforementioned fragment of a flat axe (Fig. 2–6) and can be dated to around 3800/3700 BC (Skorna 2022, 135). All

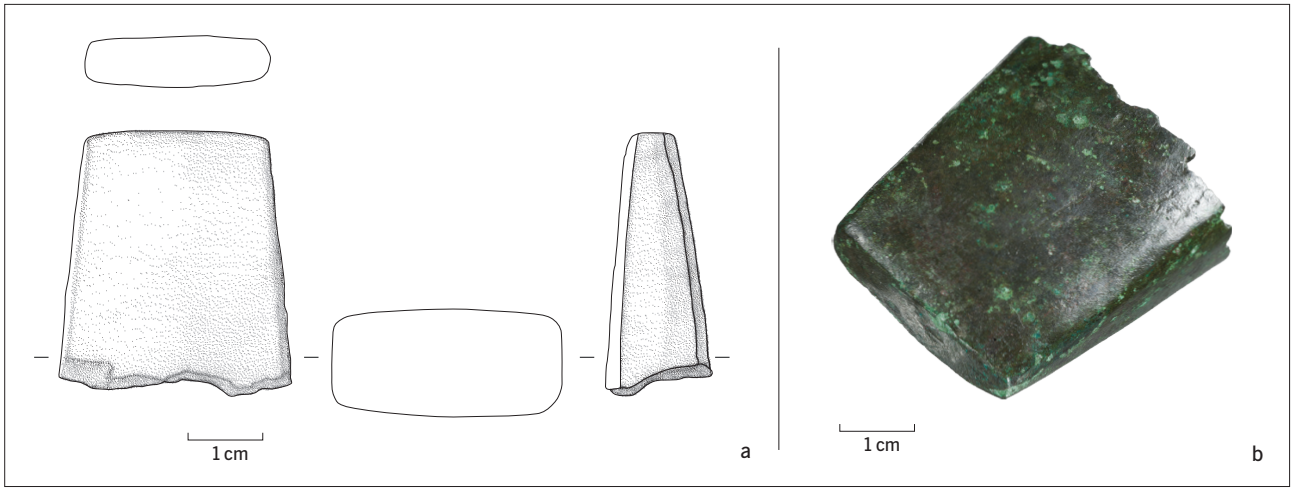

Fig. 4a–b The hot-shorted flat axe from Neuenkirchen, Mecklenburgische Seenplatte district.

Abb. 4a–b *Das warmbrüchige Flachbeil von Neuenkirchen, Lkr. Mecklenburgische Seenplatte.*

4 Amongst others, Klassen 2000 and Skorna 2022.

5 Untracht 1969, 18; Jantzen 2008; Kuijpers 2018, 127; Knight 2019, 252.

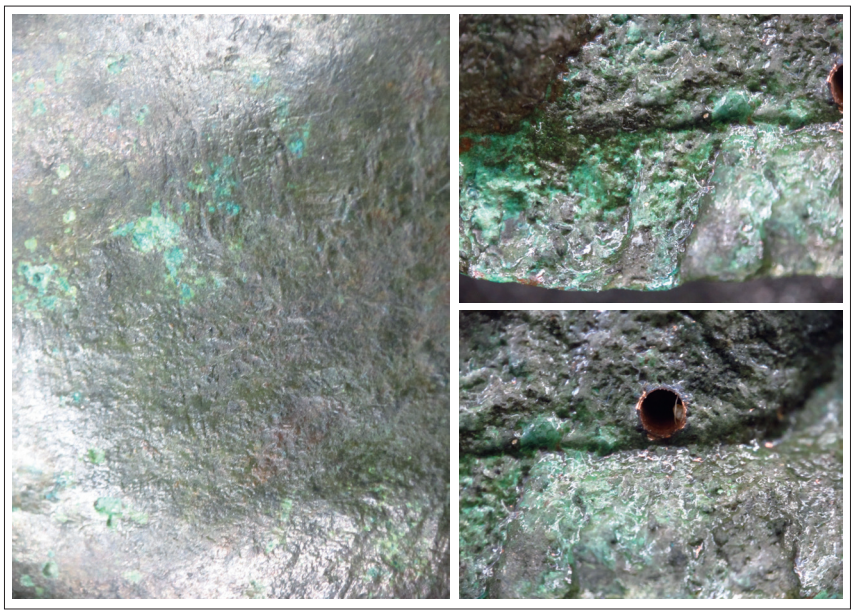

Fig. 5a–c Possible hammer mark and detailed fracture line on the flat axe of Neuenkirchen, Mecklenburgische Seenplatte district (b–c 60x magnification); no scale.

Abb. 5a–c *Mögliche Hammerspuren und Details der Bruchlinie am Flachbeil von Neuenkirchen, Lkr. Mecklenburgische Seenplatte (b–c 60-fache Vergrößerung); o. M.*

objects appear to have been intentionally destroyed before they were deposited. The dagger, the flat axe fragment, and the band spiral exhibit clear signs of the destruction process. Due to their fragile nature and limited material thickness, this cannot be determined for certain for the sheet fragment and arm spiral.

A lead isotope analysis of the flat axe fragment has shown that the metal that was used to produce the object most likely originates from the eastern Serbian mines in Madjanpek, where mining during the Chalcolithic period has been proven (Pernicka et al. 1993; Antonović 2018). The use-wear analysis revealed several scratches, indentations, and dents on the object. Some of these can be attributed to the manufacturing process: for example, some of the grinding marks, which are evidence of the effort to work out superficial casting defects (Skorna 2022, 60–61). Others can be interpreted as signs of use: for example, the smaller indentations and isolated deeper scratches. One long oval indentation on one side of the flat axe blade stands out in particular, as it can be interpreted as a hammer blow (Fig. 5; Skorna 2022, 60; 84). The most prominent feature is the hot-short fragmentation pattern, which is clearly visible through the clean and sharp break without any signs of bending of the flat axe (Fig. 5–6). Together with the hammer blow, this can be interpreted as a deliberate hot-short to fracture the flat axe before deposition. Other objects such as the dagger and the band spiral of the hoard find of Neunkirchen were also intentionally destroyed (Skorna 2022, 56–57), underlining the argumentation that the flat axe met the same fate.

Lackalända, Scania (Sweden)

Two other possible examples of hot-shorting originate from a two-piece hoard from Swedish Lackalända (Fig 3; 7), where two flat axes were deposited in a fragmented state. As these flat axes could not be examined in person by the author, one has to rely on the published illustration by Klassen (2000, Pl. 27,100A–B). Judging from the drawings, a clear fracture typical for hot-shorted objects can be observed. As this is the only example where both fragments of a hot-shorted flat axe were preserved, it is clearly visible that no bending along the longitudinal axis is present. Furthermore, there is no observable displaced material at the fracture lines, as

Fig. 6a–b The flat axe fragments of Nadrensee, Vorpommern-Greifswald district (a), and Neuenkirchen, Mecklenburgische Seenplatte district (b), exhibiting the clear sharp fracture of hot-shorts

Abb. 6a–b *Flachbeilfragmente von Nadrensee, Lkr. Vorpommern-Greifswald (a), und Neuenkirchen, Lkr. Mecklenburgische Seenplatte (b), mit der klaren, scharfen Bruchkante eines Warmbruchs.*

Fig. 7a–b The possible hot-shorts from Lackalända, Scania (a), and Nadrensee, Vorpommern-Greifswald district (b).

Abb. 7a–b *Mögliche Warmbrüche von Lackalända, Skåne (a), und Nadrensee, Lkr. Vorpommern-Greifswald (a).*

was the case, for example, with a flat axe from South Funen (Klassen 2000, Pl. 4,19). One would expect such observable displaced material if bending or forceful impacts caused the breakage. With some caution, both pieces from Lackalända can thus be classified as hot-shorts.

Nadrensee, Vorpommern-Greifswald district

The flat axe fragment from Nadrensee was found by a metal detectorist (Schirren 2008, 265). The site is roughly 70 km south-east of the site of the hoard find from Neuenkirchen (Fig. 3). The fragment likely belonged to a formerly trapezoid axe with an asymmetric cutting edge and slightly pronounced cutting corners. A clear typological classification is not possible due to the fragmented nature of the find, but several comparable examples of trapezoid axes are known from the Northern Group of the Funnel Beaker societies (e.g., from Kulebjerg Skov, Sorø Municipality [Denmark]; Klassen 2000, Pl. 7,30). Although, unfortunately, the fragment has not yet been subjected to a detailed use-wear analysis, several deeper and shallower scratches can be observed already with the naked eye. Other damage patterns, which could indicate hammer blows or other forceful impacts, are not visible. As with the flat axe from Neuenkirchen, the flat axe fragment from Nadrensee exhibits a clear and sharp fracture of a typical hot-short without visible bending along the longitudinal axis or further damage (Fig. 6–7).

As was shown above, the practice of destroying metal objects before depositing them into the ground is well known within the Funnel Beaker communities. We can therefore assume that the knowledge about the properties of copper as well as the skill of hot-working the metal were used to deliberately destroy objects, exploiting the hot-shorting of copper. Hot-shorted flat axes are therefore a telltale sign for metallurgical knowledge in the Northern Group of the Funnel Beaker societies. These hot-shorted objects implicate the presence of a metalworker with a command of pyro-technology, the necessary equipment, and sound material knowledge (Knight 2022, 158).

Conclusion – A »little« Copper Age?

The deliberate fragmentation of copper flat axes by hot-shorting constitutes compelling evidence for metallurgy in the Early Neolithic Northern Group of Funnel Beaker societies. In addition, with the metallurgical tools from Lønt and Kotowo, the evidence deepens the impression of an independent production of copper objects in the Western Baltic region during the Early Neolithic (4100/4000–3300 BC). The radiocarbon dates from Kotowo and stratigraphical and typological evidence from Lønt, as well as the typological information gathered from the hoard find of Neuenkirchen, push the start of this development back into the first centuries of the 4th millennium BC – far earlier than previously thought. The hot-shorted flat axes from Neuenkirchen and Nadrensee, and the metallurgical activities they involve, close the gap in metallurgical knowledge between Lønt and Kotowo. Mecklenburg-Western Pomerania thus appears to have served as the gateway for the transfer of knowledge as well as transformational ideas between the Eastern Group and the Northern Group of the Funnel Beaker societies. This observation strengthens the idea of the influx of such technological innovations via the Lengyel-Polgar Circle, as Żurkiewicz et al. (2023, 430) have proposed. The scarcity of metallurgical evidence is most likely due to the lack of sources, as not many larger settlements with multiple house plans (as in the Alpine pile dwellings) are known from the Western Baltic, where one would expect to find metal workshops. For example, from Mecklenburg-Western Pomerania only seven house plans are known, and the research has to rely on rare cases of good preservation such as in Lønt, where Neolithic strata were preserved under megalithic graves. Another factor could be that hot-shorted objects have perhaps not been identified as such and that, therefore, evidence for the metallurgical practice has not been recognised. Lately this hypothesis has gained more attention through the works of Kuijpers (2018) and Knight (2018), and more examples of hot-shorted material are being identified that were previously overlooked, as in the cases of Neuenkirchen, Nadrensee, and Lackalända. The variety of local forms, the growing evidence in the form of tools, and the hot-shorted flat axes point to the fact that one has to expect lively metallurgical activity, especially in the »boom time« between 3500 and 3300 BC. The evidence for mining ore and smelting is missing for the Funnel Beaker societies of the Northern Group, and they most likely had to rely on imports in the form of readymade products from the metallurgical centre of the Mondsee Group or directly from the sources in South-Eastern Europe. Nevertheless, the proven metallurgical activities are enough to propose a Copper Age in the Western Baltic region starting no later than 3500 BC and lasting only until 3300 BC.

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5 Skorna 2022, 61 Fig. 21
6 author
7 a Klassen 2000, Pl. 27,100A–B; b author

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Depositional practices of shaft-hole axes in the 4th millennium BC

Svend Hansen

Zusammenfassung

Praktiken der Deponierung von Schaftlochäxten im 4. Jahrtausend v. Chr.

In den vergangenen 20 Jahren hat sich die Verbreitung der Schaftlochäxte des 4. Jts. v. Chr. (Typen Baniabic [Bányabükk]/Vâlcele, Fajsz und Corbasca) verdichtet. Inzwischen gibt es eine Reihe von entsprechenden Funden zwischen Karpaten und Kaukasus. Dadurch lassen sich nun auch die Unterschiede der Deponierung besser verstehen. Östlich des Dnipro gelangten die Äxte als Beigabe in die Gräber sozial hochgestellter Personen. Westlich des Dnipro wurden die Äxte einzeln oder in Horten deponiert, als Gaben an die imaginären Mächte, die Geister und Götter. Diese Mechanik der Deponierung ist für das Fundbild der frühen Schaftlochäxte entscheidend. Im 3. Jt. v. Chr. wird sich dies ändern.

Schlagwörter Kaukasus, Nordpontikum, Karpatenbecken, Schaftlochäxte, Deponierungsregeln

Summary

In the past 20 years, we have gained a clearer image of the distribution of the shaft-hole axes of the 4th millennium BC (types Baniabic [Bányabükk]/Vâlcele, Fajsz, and Corbasca). Corresponding finds are known between the Carpathians and the Caucasus, shedding light on the differences in deposition. East of the Dnipro, axes were placed into the tombs of high-ranking persons as grave goods. West of the Dnipro, axes were deposited individually or in hoards, as offerings to imaginary powers, spirits, and gods. This mechanism of deposition is crucial for the find pattern of early shaft-hole axes and changed during the 3rd millennium BC.

Keywords Caucasus, North Pontic, Carpathian Basin, shaft-hole axes, deposition rules

Introduction

In recent years, large-scale networks during the 5th and 4th millennium BC, particularly based on the distribution of jadeite axes and beads made of callaite, variscite, and turquoise, were identified (Pétrequin et al. 2012; Querré et al. 2019; Viel et al. 2019). These objects circulated in regional networks as prestige goods. A network based on heavy copper axes existed in eastern Central Europe in the 5th millennium BC. In western Europe at the same time, such a network was based on the circulation of jadeite axes. But there were also exchanges between these networks, as evidenced by jadeite axes from the Balkan Peninsula. We can therefore assume that there were practically no isolated regions in the 4th millennium BC, but that they were all connected in one way or another. Thus, the axes discussed below should also be considered as evidence of communication between the Caucasus and the neighbouring regions to the west as far as the Carpathian Basin and, finally, central Germany. In the case of copper and bronze axes, however, depositional practices must be taken into account.

The shaft-hole axe

The shaft-hole axe was one of the most striking innovations in the history of Eurasian armament (Fig. 1). It was extremely successful, for its manufacture apparently succeeded without major problems in many regions between the Taurus and Caucasus mountains in the East and as far as the Alps in the West. It was part of other technical innovations such as arsenic bronze, which took place in the Caucasus region. Guillaume Gernez refers to a »zone of conceptual and technical innovation« with regard to the development of weapons from the Caucasus, including eastern Anatolia (Gernez 2017, 43).

According to radiocarbon dating, the development of these shaft-hole axes started in the second quarter of the 4th millennium (see below Fig. 14). In grave 70 of the 6.5-m high kurgan 1 near Zamankul in North Ossetia (Russia) the remains of a 40- to 45-year-old man and a 20- to 25-year-old woman were found (Korenevskij/Rostunov 2004). The grave goods include a set of tools, a bronze adze, a flat axe, and a shaft-hole axe (Fig. 2). The bronze vessel was probably the most valuable grave good. All these objects were made from arsenical bronze (Hansen 2021).

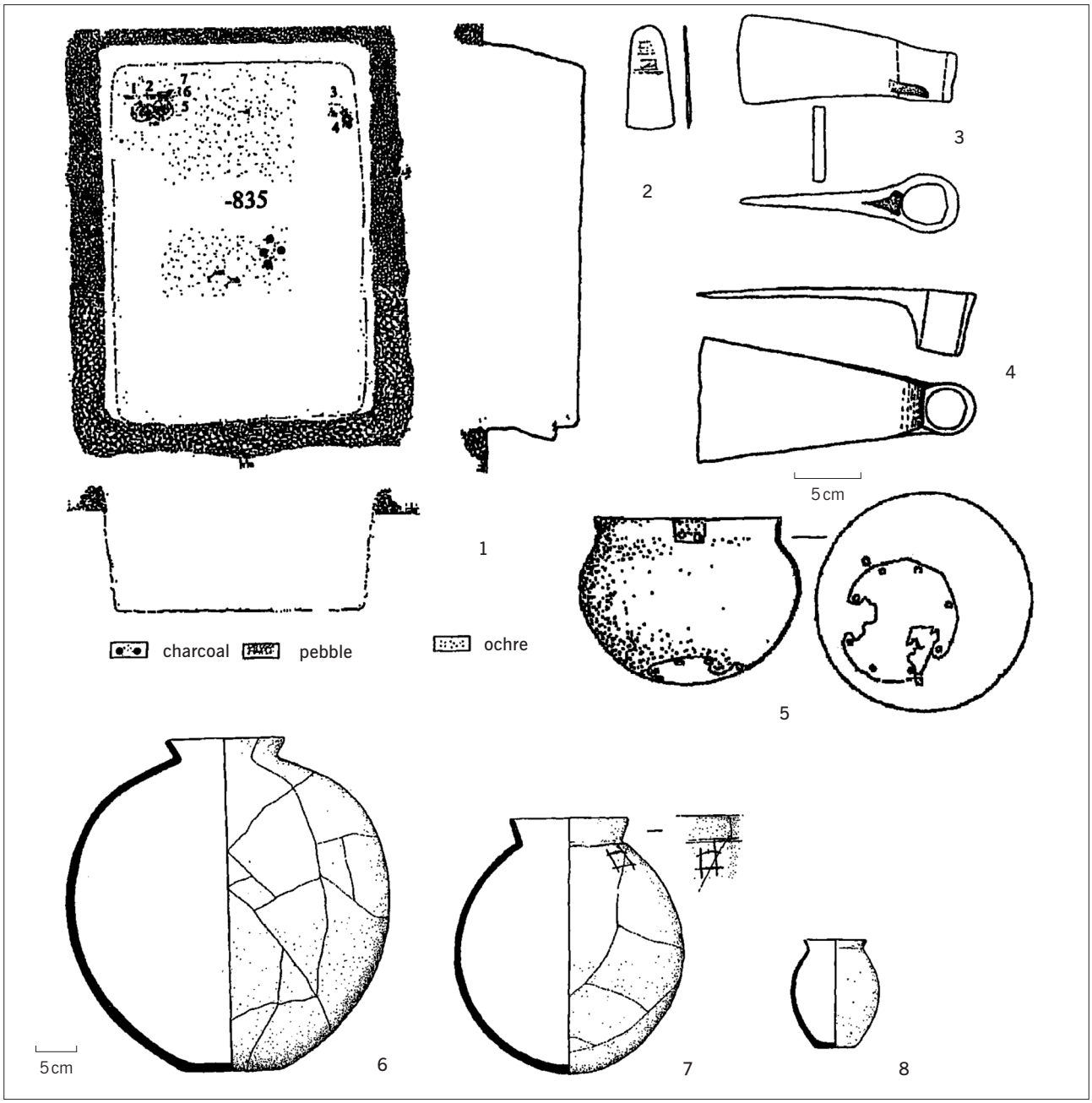
One of the earliest burial complexes with a shaft-hole axe is the eponymous tomb of Maikop (Russia; Piotrovskij 2020). Whereas it was long dated to the 3rd millennium BC, today there is a wide consensus that it was built before the middle of the 4th millennium BC. The deceased was given a functional set of arsenic bronze tools (Fig. 3): an adze, an axe-adze, two flat axes, two gouges, a small and a large dagger, and a shaft-hole axe. It is the most complete

Fig. 1 A shaft-hole axe from Dolný Pial, okr. Levice (Slovakia).

Abb. 1 *Schaftlochaxt aus Dolný Pial, Okres Levice (Alsópél/Unterpill, Bezirk Léva/Lewenz; Slowakei).*

Fig. 2 The grave goods of Kurgan 1 near Zamankul, Pravoberezhny district (Russia).

Abb. 2 *Grabbeigaben aus Kurgan 1 bei Zamankul, Region Pravoberezhny (Russland).*



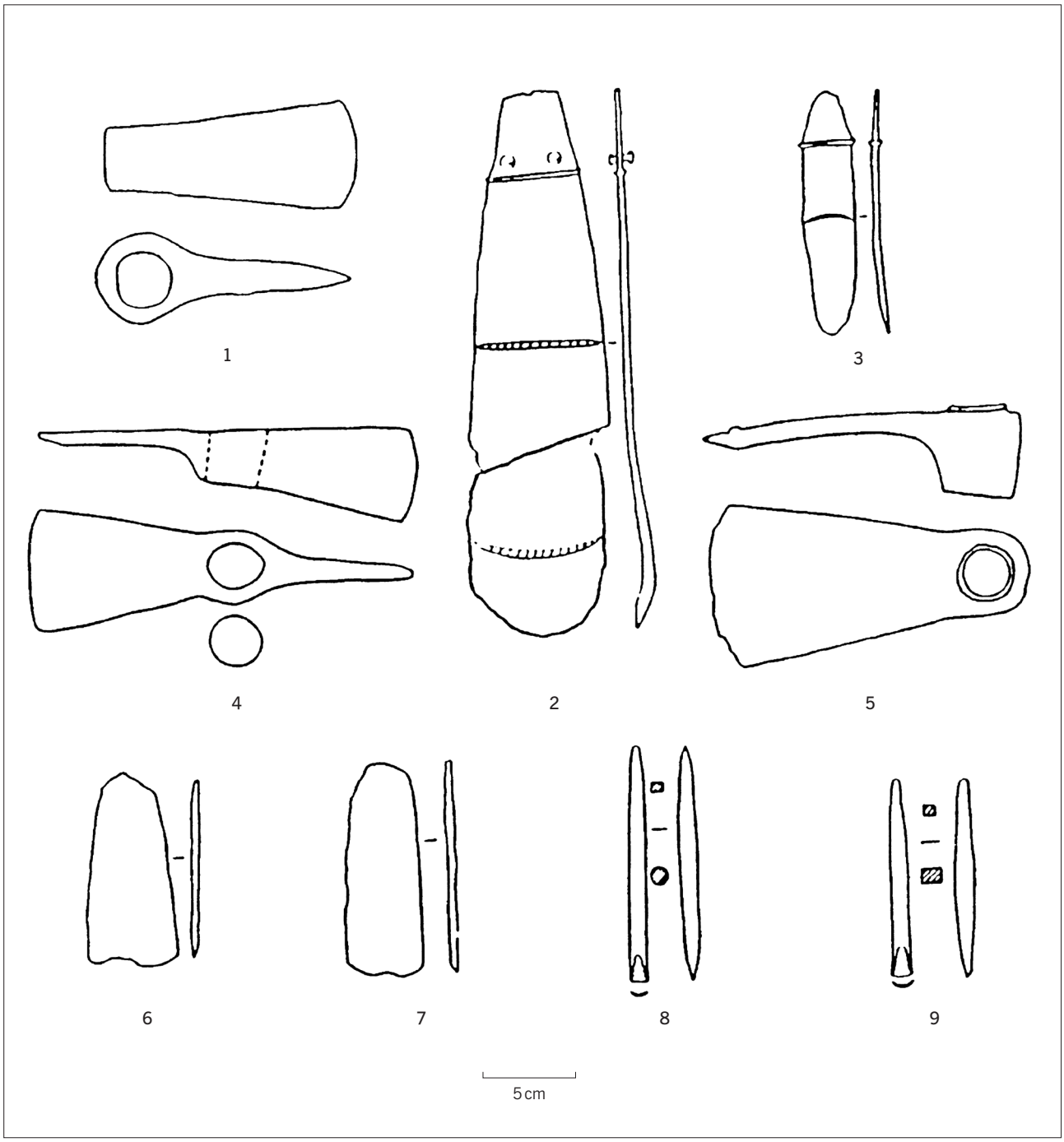


Fig. 3 One of the earliest examples of a shaft-hole axe deposited as a grave good. Kurgan in Maikop, Rep. Adygea (Russia).

Abb. 3 *Eines der frühesten Beispiele für eine Schaftlochaxt als Grabbeigabe. Kurgan in Maikop, Rep. Adygeja (Russland).*

»toolbox« in any find complex. Furthermore, the tomb was furnished with gold, silver, and bronze vessels, golden beads and golden appliques in the shape of lions, and two silver and two golden bulls (Hansen 2014).

The burial mound of Inozemtsevo (Russia), located between Pyatigorsk and Mineralnye Vody, was originally over 7 m high and 50 m in diameter. It contained a central (unfortunately pillaged) burial of a 55- to 60-year-old man (Korenevskij/Petrenko 1982). Among the grave goods, only a few gold beads and a few strips of gold sheet bear witness to what was probably originally a much more extensive endowment made of precious metal (Fig. 4). Three metal vessels belong to the technically most advanced products of that time. The tool kit consists of two shaft-hole axes, a flat axe, two bronze daggers, and several arrowheads made of flint.

In tomb 18 of Kurgan 1 of the tumulus necropolis of Mar'inskaya 3, raion Kirov, krai Stavropol (Russia), was a richly furnished grave with an early shaft-hole axe, two knives, a dagger, a flat axe, and two awls (Kantorovič/Maslov 2008) (Fig. 5). Further, the most important finds are a stone sceptre and two golden rings, which indicate the high social status of the deceased person. The grave can be dated to around 3350 BC, according to radiocarbon dates.

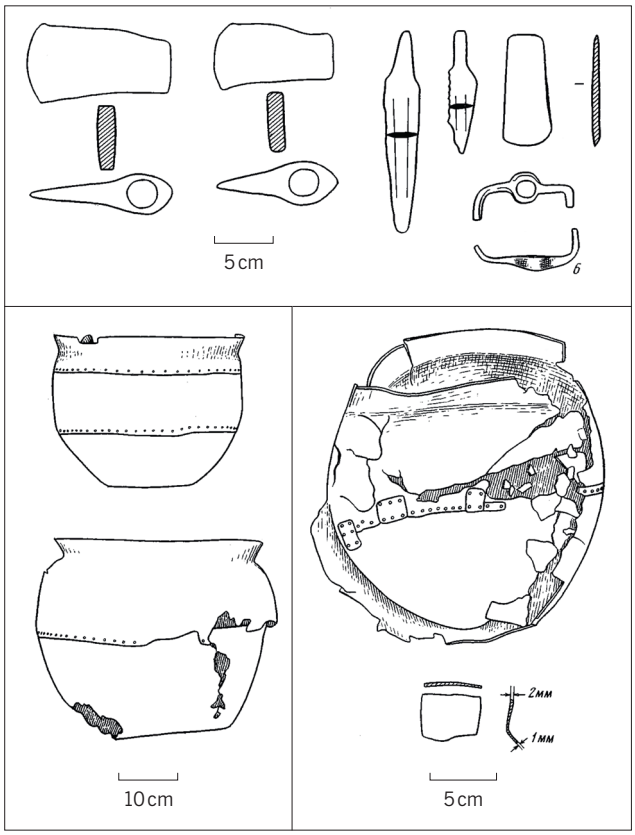


Fig. 4 The grave goods of the robbed burial mound of Inozemtsevo, Stavropol Krai (Russia).

Abb. 4 *Beigaben aus dem ausgeraubten Grabhügel von Inozemtsevo, Stavropol Kraj (Russland).*

Fig. 5 Find assemblage unearthed in the richly furnished grave of tomb 18, Kurgan 1, Mar'inskaya 3, Stavropol Krai (Russia).

Abb. 5 *Fundkomplex aus dem reich ausgestatteten Grab 18, Kurgan 1, Mar'inskaja 3, Stavropol Kraj (Russland).*

In 1898, Nikolai Veselovsky found a stone »house«-shaped burial chamber in Kurgan I of Novosvobodnaya (formerly Tsarskaya, Russia). The grave goods consisted of golden and silver pins, rings and beads, a bronze vessel, a hook mounted with figures of two fighting men, a dagger, two gouges, and two axes (Gimbutas 1956, 60 f. Fig. 30) (Fig. 6). The ^{14}C-dating for this burial falls within the last quarter of the 4th millennium BC (Korenevskij/Rezepkin 2008).

The richest grave of the Novosvobodnaya cemetery was grave 5 of Kurgan 31, which contained the burial of an adult and a child. The grave goods found there consisted of four shaft-hole axes, two further axes with neck knobs, numerous daggers, two gouges, and numerous other metal grave goods (Fig. 7–8). Noteworthy for this grave is the 65-cm-long bent sword (Fig. 9) (Rezepkin 2012, 91 Tab. 6). One ^{14}C-dating (Ki-13822) lies in the 1σ area between 3701 and 3384 cal BC, and the other ^{14}C-dating (Ki-13822a) lies between 3642 and 3378 cal BC. Unlike in Maikop, we are not dealing with a functional tool set in this grave, but with a surplus of equipment: an »Überausstattung« (Hansen 2002). The deceased would never have been able to use all the axes and daggers.

With slight variations, the shape of the axes remained relatively constant until the end of the 4th millennium BC, as the two shaft-hole axes from the great kurgan of Nalčik (Russia) show, which, according to a ^{14}C date, might belong to the 30th century BC (Čečenov 1973; Belinskij et al. 2017) (Fig. 10). In addition to the two axes, a chisel with hollow edge and a flat axe were part of the tool kit.

West of the Caucasus on the Crimea, there is another important piece of evidence for an early shaft-hole axe. The central grave 3 in Kurgan 1 (Kurban-Bayramı) of Dolinka, rajon Krasnoperekopsk (Ukraine), contained, apart from the shaft-hole axe, a gouge, a flat axe, and a fork-shaped object (Fig. 11). The recently published ^{14}C date proves that the grave dates between 3500 and 3300 BC (Ivanova/Rassmann 2014, 214). Another find of Maikop-type objects from a quarry near Krasnoperekopsk (Ukraine) in the Crimea consists of an axe measuring only 8 cm, a flat axe, a chisel, and a dagger (Klochko/Kozymenko 2017, 45 Fig. 1) (Fig. 12).

These axes were part of richly furnished graves and large kurgans in the North Caucasus and on the Crimea. Although the earliest burial mounds were created in Brittany (e.g. Tumiac) in the 5th millennium BC, it was during the Mai-

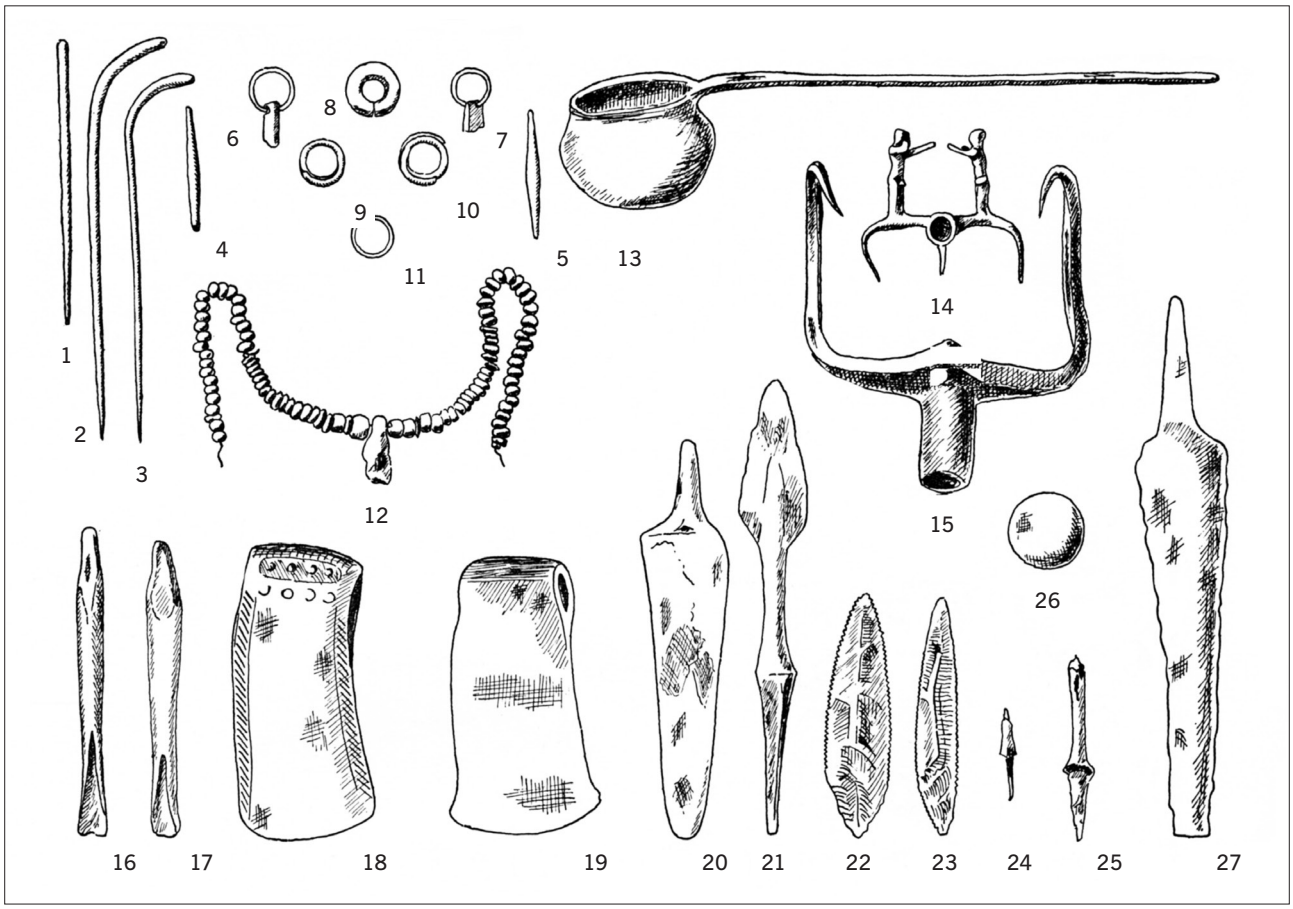


Fig. 6 Objects found in the »house«-shaped burial chamber in Kurgan I of Novosvobodnaya, Maykopsky district (Russia); no scale.

Abb. 6 *Funde aus der »Haus«-förmigen Grabkammer in Kurgan I von Novosvobodnaja, Rajon Maikop (Russland); o. M.*

kop Culture of the 4th millennium BC that burial mounds first became a structural component of funeral ideology. Giulio Palumbi interpreted the direct relationship between the size of the kurgans, the complexity of the grave structures, and the concentration of spectacular metal offerings as a funerary ideology, which was meant to emphasise the formation of internally hierarchised communities founded on vertical social relations (Palumbi 2012, 55 Fig. 4–7). He understands the embedding of these hills in the landscape as a strategy of naturalising social organisation. The burial mound becomes part of the landscape, and the structure of social inequality connected with it, more precisely, materialised in it, thus becomes part of nature.

Shaft-hole axes in the North Pontic and the Carpathian Basin

The similarities in shape between the axes from the grave of Maikop and other Early Bronze Age graves in the North Caucasus and the early shaft-hole axes in the Carpathian Basin were noted early on. Yet Alexandru Vulpe wanted »to explain by chance or leave unexplained for the time being the surprising formal similarities between the axe type Baniabic [today Vâlcele, S.H.] and axes from the North Caucasus and Central Russia [...]. No such objects are known from the intermediate zone« (Vulpe 1970, 26). Unfortunately, this conclusion was already more than improbable when it was published, over 50 years ago. Instead, the similarity in form should be the starting point for a number of revisions of terminology and dating.

Shaft-hole axes of the types Baniabic/Vâlcele, Fajsz, and Corbasca, according to Alexandru Vulpe, have in common their compact, »plump« outlines. The shaft hole is as long as the axe blade. The more developed axes of the Kozarac type have a shaft hole longer than the axe blade (Fig. 13). Therefore the »plump« shaft-hole axes should be named the Vâlcele-Maikop type to describe their typological similarities and spatial dimensions.

The consequences for their dating are quite clear. Joszef Bátora already showed that the typologically more developed Kozarac axes (see Fig. 13), according to radiocarbon dates, belong to the early 3rd millennium BC (Casa 1995, 572; Primas 1996, 48 Tab. 4.2; Bátora 2003). This leaves open the possibility of an older dating for the axes of the Vâlcele-Maikop and Fajsz type. The radiocarbon data consistently show that the plump shaft-hole axes in the North Caucasus range from the second quarter of the 4th millennium to the 3rd millennium BC (Fig. 14). These axes were in use roughly between 3700 and 2900 BC.

The main difference between Caucasian and Carpathian axes is the metal composition. Caucasian axes were produced from arsenical bronze, whereas the Carpathian axes are either made from pure copper or with only 1–2 % of arsenic.

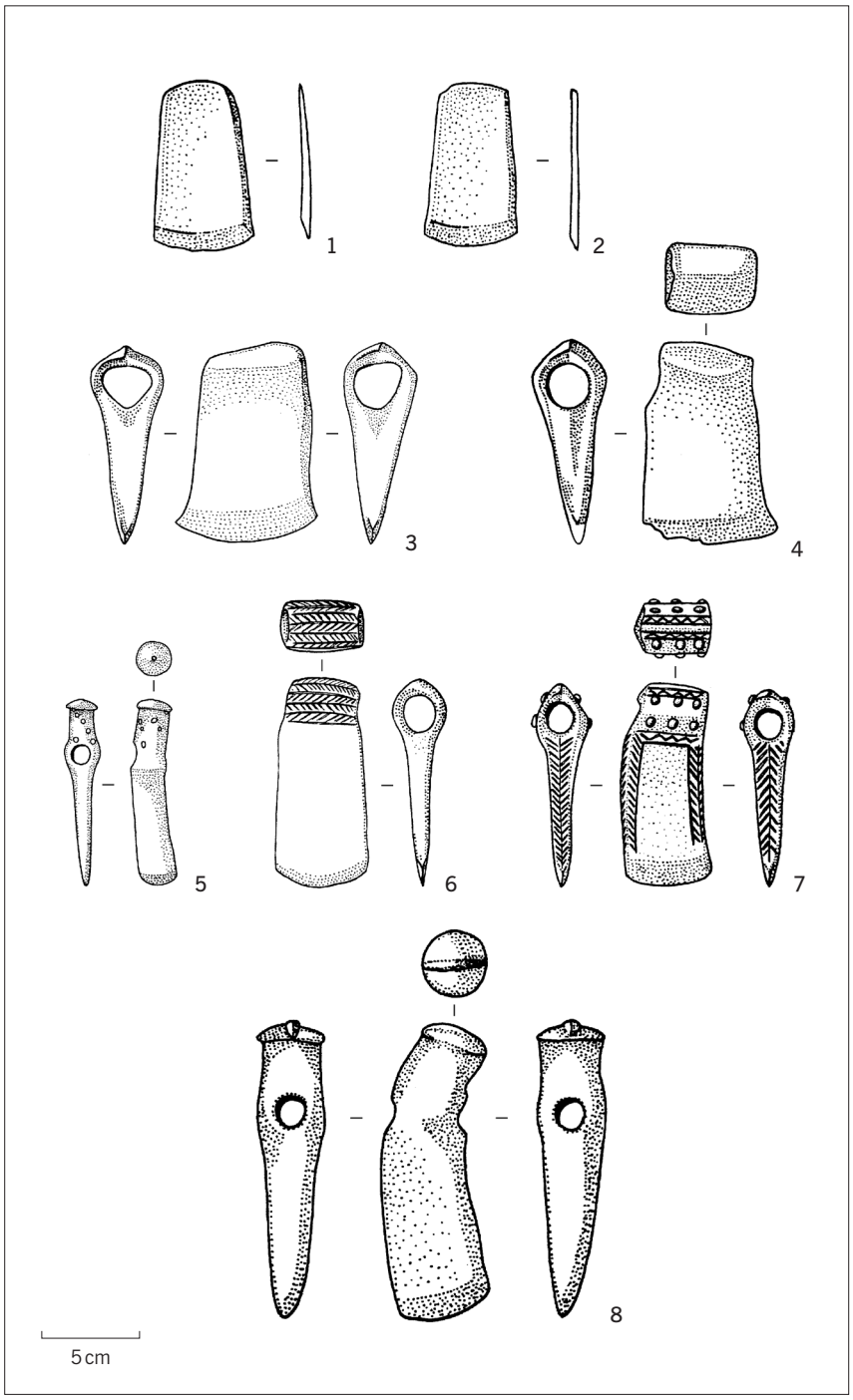


Fig. 7 Grave goods of grave 5, Kurgan 31, at Novosvobodnaya cemetery, Maykopsky district (Russia).

Abb. 7 *Beigaben aus Grab 5, Kurgan 31 der Nekropole von Novosvobodnaja, Rajon Maikop (Russland).*

With the early dating of the grave of Maykop to before the middle of the 4th millennium BC, the Carpathian shaft-hole axes with »plump« outlines, i.e. the Baniabic and Fajsz types in the Carpathian Basin, also move into the second half of the 4th millennium BC (Hansen 2011). Radu Băjenaru, Alin Frînculeasa, Vajk Szeverényi, Janos Dani, and Bianca Preda have also drawn comparable chronological conclusions in their studies[1]. Volker Heyd and Katherine Walker, on the other hand, think that the shaft-hole axes did not appear in the Carpathian Basin until around 3000 BC (Heyd/Walker 2014, 676 Fig. 35,1). In their overview table, the gap is clearly visible and allegedly existed between the last axe-adzes of the Nógrád-marcal type around 3700 BC and the first shaft-hole axes around 3000 BC. Nonetheless, a 700-year-long gap in the use of heavy metal axes probably did not exist, nor did the geographical gap exist between the Carpathians and the Caucasus (see Dobeš in this volume). In 2003, Joszef Bátora discussed a series of early shaft-hole axes found between the Caucasus and the Carpathians (Bátora 2003).

1 Băjenaru/Frînculeasa 2014; Szeverényi 2013; Dani 2013; Preda 2015.

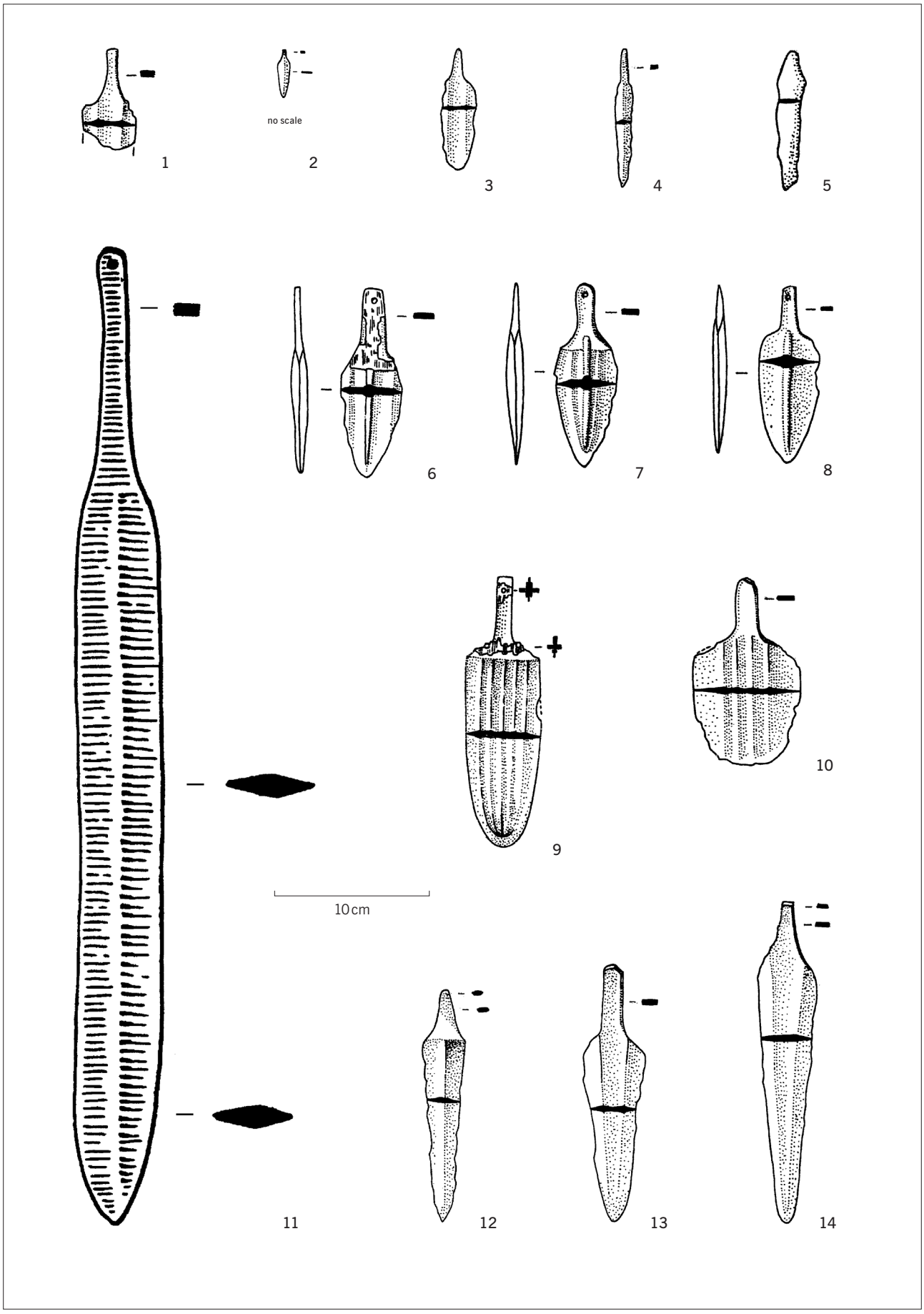


Fig. 8 Grave goods of grave 5, Kurgan 31, at Novosvobodnaya cemetery, Maykopsky district (Russia).

Abb. 8 *Beigaben aus Grab 5, Kurgan 31 der Nekropole von Novosvobodnaja, Rajon Majkop (Russland).*

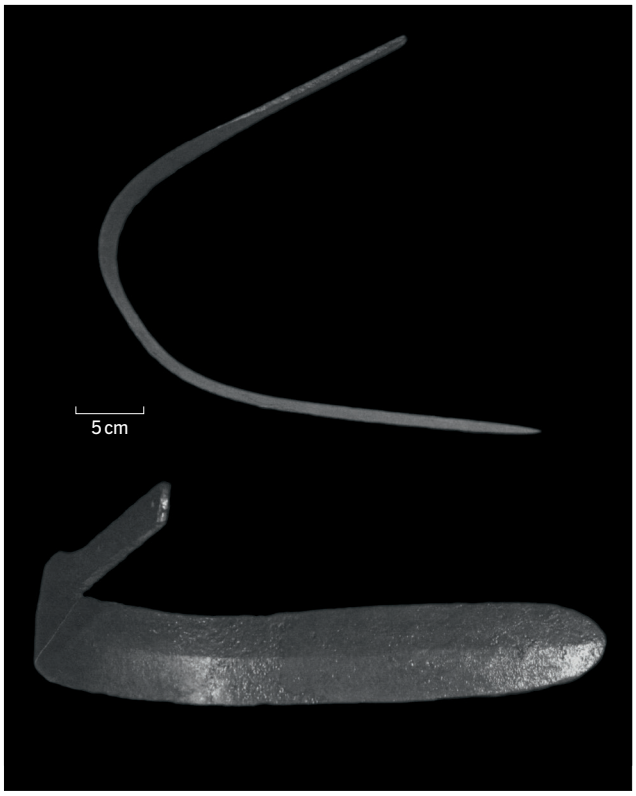


Fig. 9 The sword in Kurgan 31, grave 5, at Novosvobodnaya cemetery, Maykopsky district (Russia), was bent to make it unusable.

Abb. 9 *Das Schwert aus Grab 5, Kurgan 31 der Nekropole von Novosvobodnaja, Rajon Majkop (Russland), war durch Verbiegen intentionell unbrauchbar gemacht.*

Fig. 10 The two shaft-hole axes, a flat axe, and a chisel were found in the great kurgan of Nalčik, Rep. Kabardino-Balkaria (Russia).

Abb. 10 *Die beiden Schaftlochäxte, ein Flachbeil und ein Meißel aus dem großen Kurgan von Naltschik, Rep. Kabardino-Balkarien (Russland).*

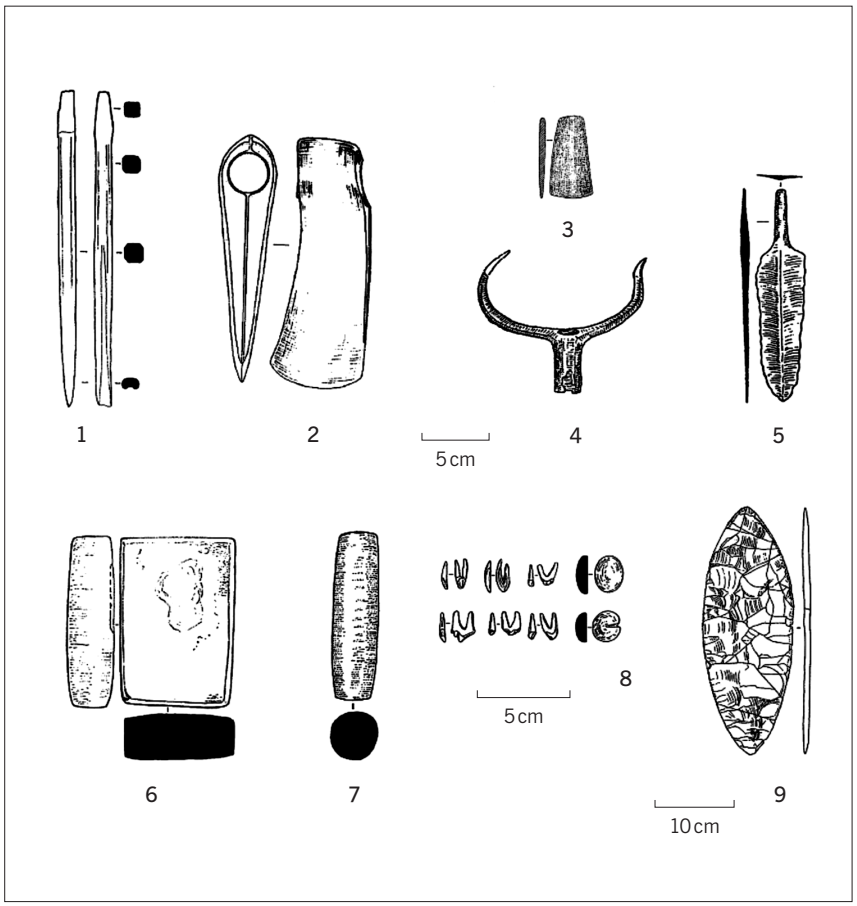


Fig. 11 Grave goods from Dolinka (Kurban-Bayram), Crimea (Ukraine).

Abb. 11 *Grabbeigaben aus Dolynka (Kurban-Bajram), Krim (Ukraine).*

Fig. 12 Finds from a destroyed grave near Krasnoperekopsk, Crimea (Ukraine).

Abb. 12 *Funde aus einem gestörten Grab bei Krasnoperekopsk, Krim (Ukraine).*

And since then, comparable early axes from the »intermediate zone« between the Caucasus and the Carpathians have been found in hoards. Here, the wedge-shaped shaft-hole axe found together with several short swords in Ivan'ky, Cherkasy Oblast (Ukraine; Fig. 15), should be mentioned (Klochko/Klochko 2013, 50 Fig. 8). Other axes are known as single finds along the Dnipro River[2]. The hoard of Ivonivka, Vinnytsia Oblast in Podolia (Ukraine; Fig. 16), includes a Vâlcele-type shaft-hole axe, two flat axes, and a chisel (Klochko/Kozymenko 2017, 52 Fig. 16).

In the Carpathian Basin, the find of Vâlcele (Baniabic, Bányabükk) near Cluj (Romania; Fig. 17) is the most significant deposition and probably originally contained more than 70 axes (Vulpe 1970, 27,1–32; Taf. 1–3.25–32; Soroceanu 2012, 109 ff. Pl. 37–42). Vâlcele thus represents the most extensive deposition of the 4th millennium BC in Europe. The axes preserved in the museums of Debrecen and Cluj weigh between 800 g and 1420 g. Eight axes weigh less than 1000 g, and 16 axes weigh more than 1000 g. Hence, probably much more than 70 kg of copper were deposited. Vâlcele represents the class of monotype hoards with only the same type of axes. This also applies to another group of hoards with only two axes: Žitavany, okr. Zlaté Moravce (Slovakia; Fig. 18, 1–2), and Kisbér, Kom. Komárom-Esztergom (Hungary; Fig. 18,3–4).

The hoard from Fajsz, Kom. Bács-Kiskun, in the South Hungarian Plain, most of which is lost today, had a more complex composition containing three axes and two chisels (Hampel 1903, 427) (Fig. 19). Unfortunately, nothing more is known about the circumstances of its discovery.

The hoard from Brno-Lišeň (Czech Republic; Fig. 20) in Moravia was found in the Staré Zámky hilltop settlement in the youngest settlement layer I, whose pottery partly still corresponds to the Jevišovice C1-phase, but

2 Nechitailo 1991, 30 Fig. 4,1–4: Staiki, region Kyiv; Verkhn'odniprovs'k, Oblast Dnipropetrovsk (Ukraine); Balki, Oblast Zaporizhzhe (Ukraine).

Fig. 13 Shaft-hole axe of Kozarac type. Unknown provenance.

Abb. 13 *Schaftlochaxt vom Typ Kozarac. Fundort unbekannt.*

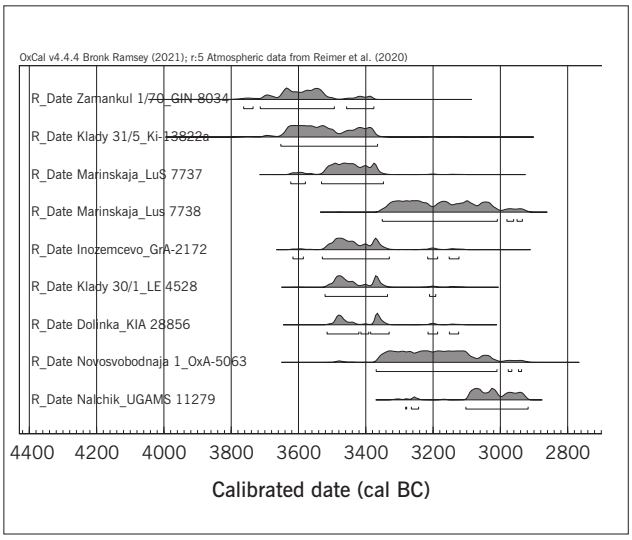


Fig. 14 Radiocarbon dates.

Abb. 14 *Radiokarbondatierungen.*

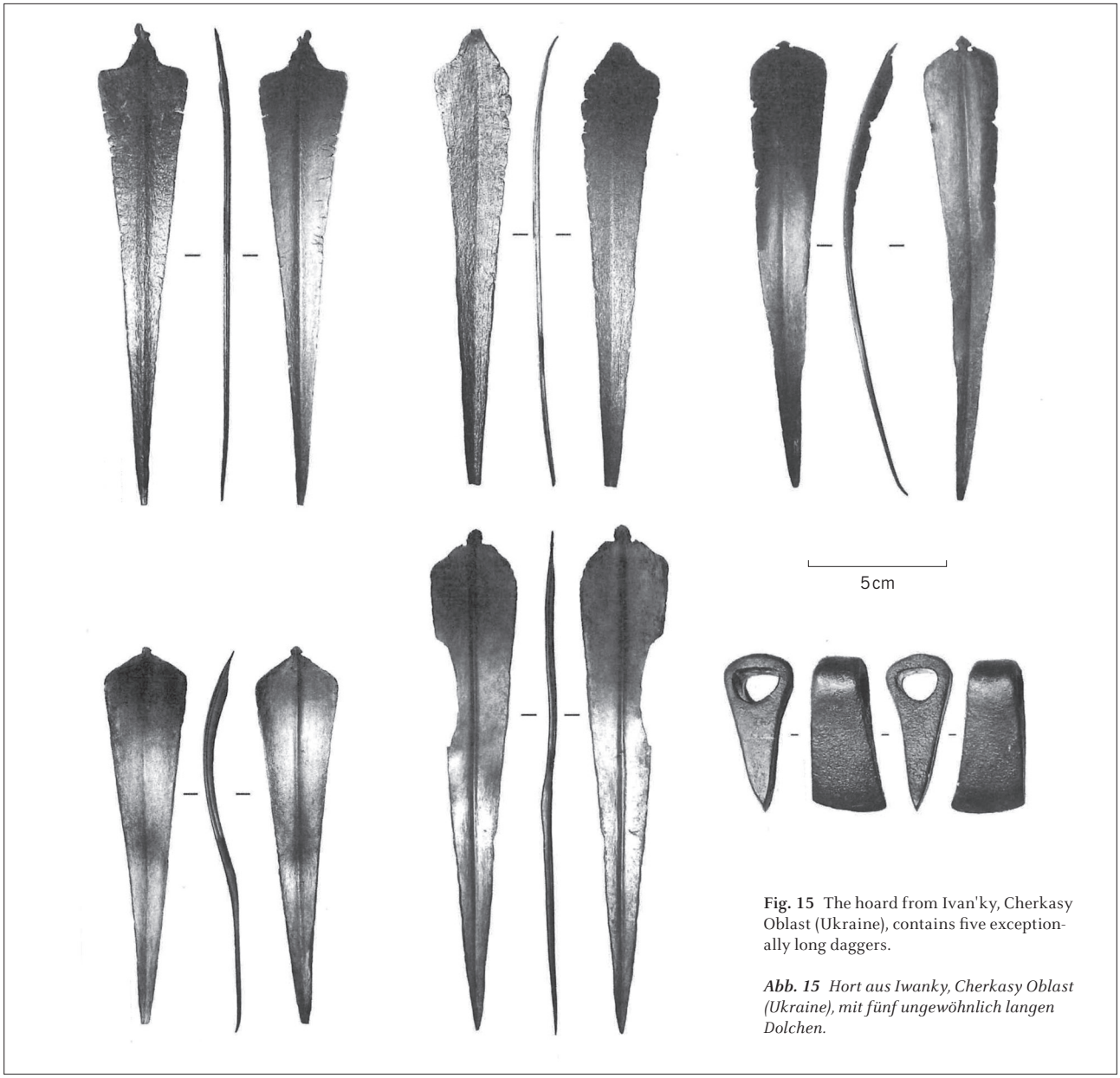


Fig. 15 The hoard from Ivan'ky, Cherkasy Oblast (Ukraine), contains five exceptionally long daggers.

Abb. 15 *Hort aus Iwanky, Cherkasy Oblast (Ukraine), mit fünf ungewöhnlich langen Dolchen.*

Fig. 16 A shaft-hole axe, flat axes, and a chisel from Ivonivka, Vinnytsia Oblast (Ukraine).

Abb. 16 *Schaftlochaxt, Flachbeile und ein Meißel aus Ivanivka, Oblast Winnyzja (Ukraine).*

mainly to Jevišovice B (Benešová 1956). According to Martin Furholt, the Jevišovice B group appeared in Moravia as of 3100 BC (Furholt 2013). Therefore, the hoard is not dated more precisely, but the available data does not contradict an assignment of the axe to the late 4th millennium BC[3].

The most noticeable argument for the close connections between the Carpathians and the Caucasus are the other tools in the hoard: the flat axe and the chisel with a pyramid-shaped shaft, which is typical for Caucasian chisels. A hoard like the one in Brno-Lišeň could also have been used as a functional tool kit in a grave in the North Caucasus. The objects lay crossed, one on top of the other – a common way of placing Early Metal Age weapon sets in graves. The grave of Vozdvizhenskaya (Russia; Fig. 21) is mentioned here as an example of such a set of functional weapons and equipment (Popova 1963).

Remarkably, the hoard of Brno-Lišeň is also significant because it holds a combination of types: not only the shaft-hole axe, but also the flat axe and the chisel with pyramid-shaped shaft, which are also common in the Caucasus (Munchaev 1994, 206 Fig. 54).

In two other hoards from Moravia, the chisel is missing. They contain only the shaft-hole axe and a flat axe (Fig. 22). In Stavenice, okr. Šumperk (Czech Republic), the Corbasca-type axe was found together with a flat axe (Rudimov type) which is dated into the late 4th and early 3rd millennium BC (Dobeš et al. 2019, 18 Abb. 11,3–4; 21 Nr. 117). The hoard was deposited on a south-facing slope. The circumstances of the discovery of the hoard of Vevčice, okr. Znojmo (Czech Republic), are not known (Říhovský 1992, 37; 68; Taf. 5,35; 11,116).

In the Carpathian Basin, the early shaft-hole axes were often deposited as single objects[4]. Unfortunately, the circumstances under which they were found usually cannot be described in more detail. One exception is the axe from Hărău, jud. Hunedoara (Romania; Fig. 23), which was recently published extensively by Catalin Nicolae Rişcuţa (2016). The axe consisting of almost pure copper was found on a spur outside a defined settlement area and is interpreted as an intentional deposition. The axe of type Fajsz is

3 The ^{14}C date for Brno-Starý Lískovec listed in Tab. 10 in Kaiser 2019, 237 (and also already in Ivanova 2016, 407) is irrelevant for dating the axe from Brno-Staré Zámky, because it is from a different settlement.

4 Map in Dani 2013; the axe type Fajsz found in Sasa (Bejinariu/Kadar 2003; Kadar 2007, Taf. 28,114).

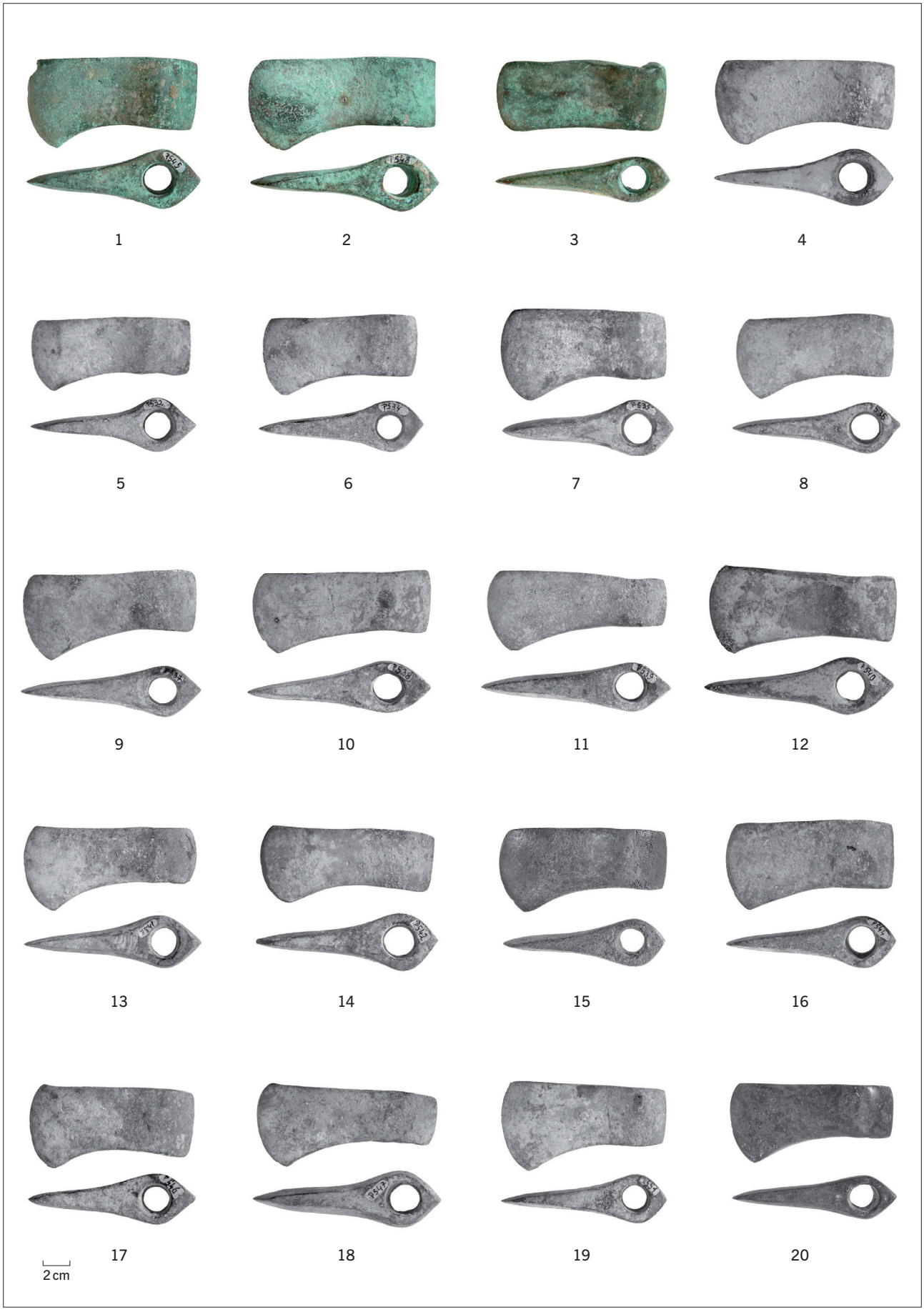


Fig. 17 The hoard from Vâlcele near Cluj (Romania) is one of the most extensive Copper Age depositions in South-east Europe.

Abb. 17 *Der Hort aus Vâlcele bei Cluj (Rumänien) ist einer der umfangreichsten kupferzeitlichen Depotfunde in Südosteuropa.*

Fig. 18 Two-axe hoards from Žitavany, okr. Zlaté Moravce (Slovakia) (1–2), and Kisbér (Hungary) (3–4).

Abb. 18 *Zweiaxthorte aus Žitavany, Okres Zlaté Moravce (Slowakei) (1–2), und Kisbér (Beer) (Ungarn) (3–4).*

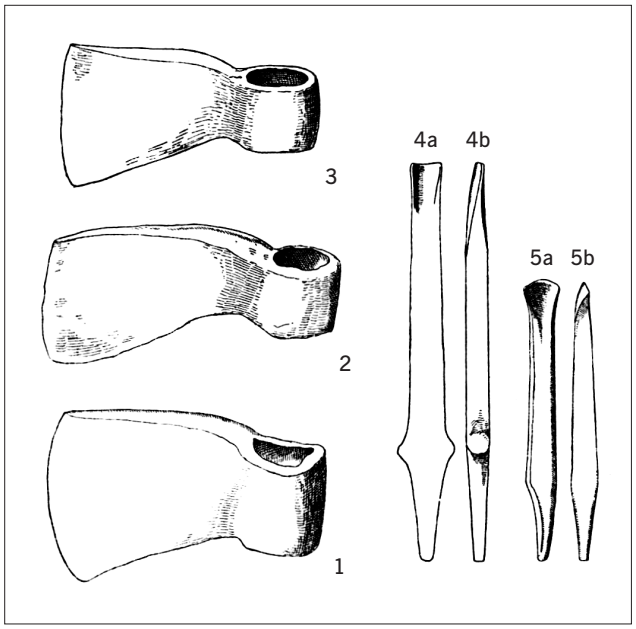


Fig. 19 Most objects from the hoard of Fajsz, Kom. Bács-Kiskun (Hungary), are lost today; no scale.

Abb. 19 *Ein Großteil der Fundstücke aus dem Hort von Fajsz, Komitat Bács-Kiskun (Ungarn), ist verschollen; o. M.*

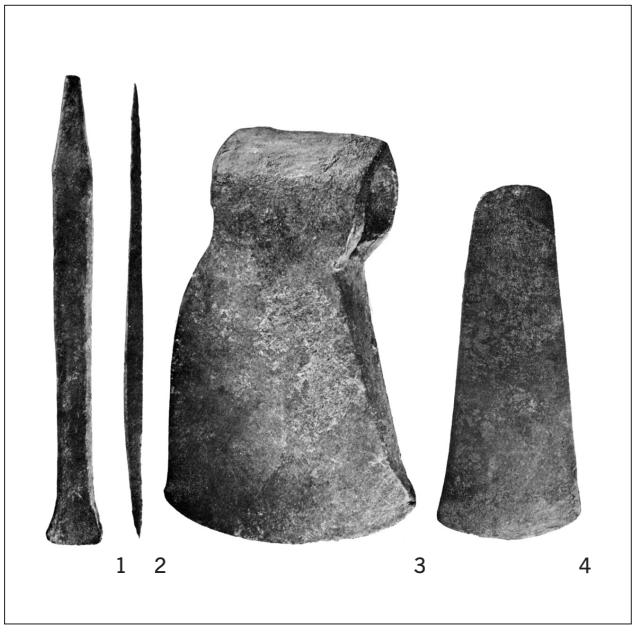


Fig. 20 The hoard of Brno-Lišeň (Czech Republic) contained not only the axe but also a chisel and a flat adze of Caucasian type; no scale.

Abb. 20 *Der Hort von Brno-Lišeň (Brünn-Lösch; Tschechien), enthielt nicht nur eine Axt, sondern auch einen Meißel und einen Flachdechsel vom kaukasischen Typ; o. M.*

Fig. 21 Grave goods from Vozdvizhenskaya, Krasnodar krai (Russia).

Abb. 21 *Grabbeigaben aus Vozdviženskaja, Region Krasnodar (Russland).*

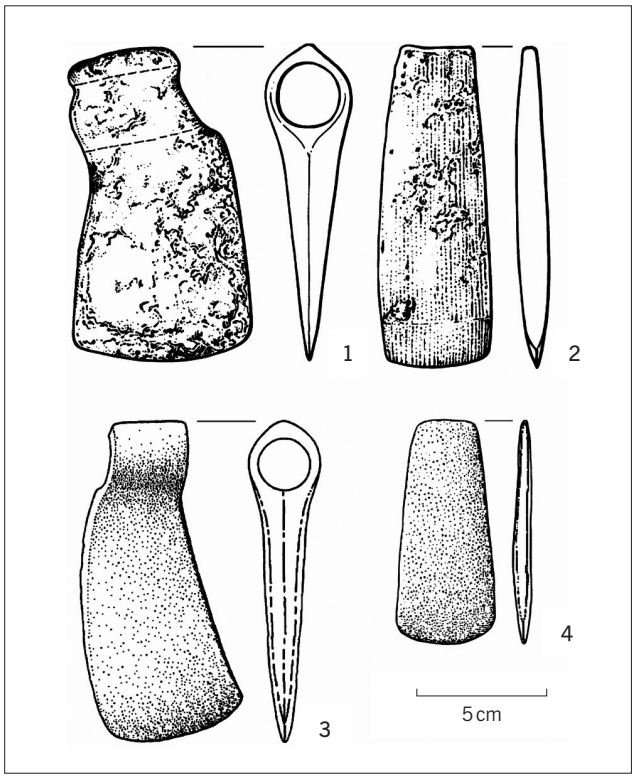


Fig. 22 The hoards of Stavenice, okr. Šumperk (1–2), and Vevčice, okr. Znojmo (3–4) (both Czech Republic), represent a hoard type.

Abb. 22 *Die Horte von Stavenice, Okres Šumperk (1–2) (Steinmetz, Bezirk Mährisch Schönberg), und Vevčice, Okres Znojmo (3–4) (Wewtschitz, Bezirk Znaim; beide Tschechien), gehören zum selben Horttyp.*

Fig. 23 The axe from Hărău, jud. Hunedoara (Romania), was a single deposition.

Abb. 23 *Die Axt von Hărău (Harró/Haren), Kreis Hunedoara (Vajdahunyad/Eisenmarkt; Rumänien), stellt eine Einzeldeponierung dar.*

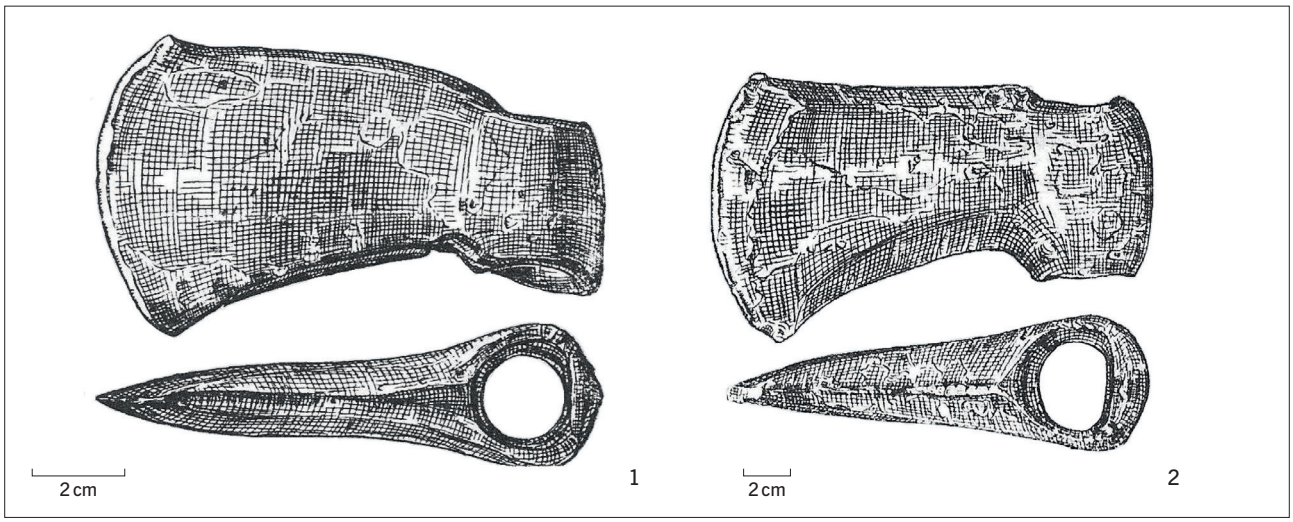


Fig. 24 Shaft-hole axes came until Brachwitz, Saalekreis district (1), and Zscheiplitz, Burgenlandkreis district (2) (both Germany).

Abb. 24 *Schaftlochäxte waren bis Brachwitz, Saalekreis (1), und Zscheiplitz, Burgenlandkreis (2) (beide Deutschland), verbreitet.*

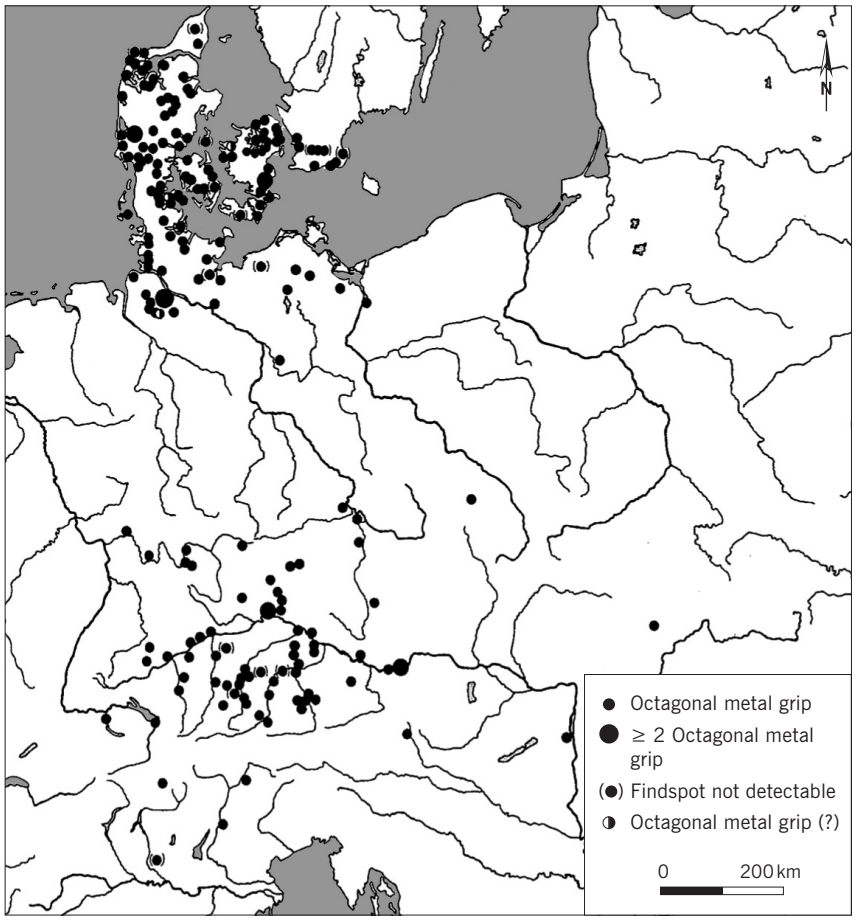
damaged at the shaft hole; it is very similar to the axe from Brno-Lišeň (see Fig. 20).

Another single find is from Slovakian Dolný Pial, okr. Levice, and is very similar (see Fig. 1; Vladár 1970). According to the spectral analysis, it consists of copper with an arsenic content of less than 1 %. For the axe from Brachwitz, Saalekreis district (Germany), 1 % arsenic is recorded, and for the axe from Zscheiplitz, Burgenlandkreis district (Germany) 0 % (Fig. 24)[5].

5 Mildenberger 1950; Kaufmann 2002; SAM 41532 Zscheiplitz.

Fig. 25 The distribution map of the Middle Bronze Age swords with octagonal metal grip can be considered as an example of the influence of deposition practices on the archaeological record.

Abb. 25 *Die Verbreitungskarte der mittelbronzezeitlichen Achtkantschwerter kann als Beispiel für den Einfluss von Deponierungspraktiken auf den archäologischen Befund betrachtet werden.*



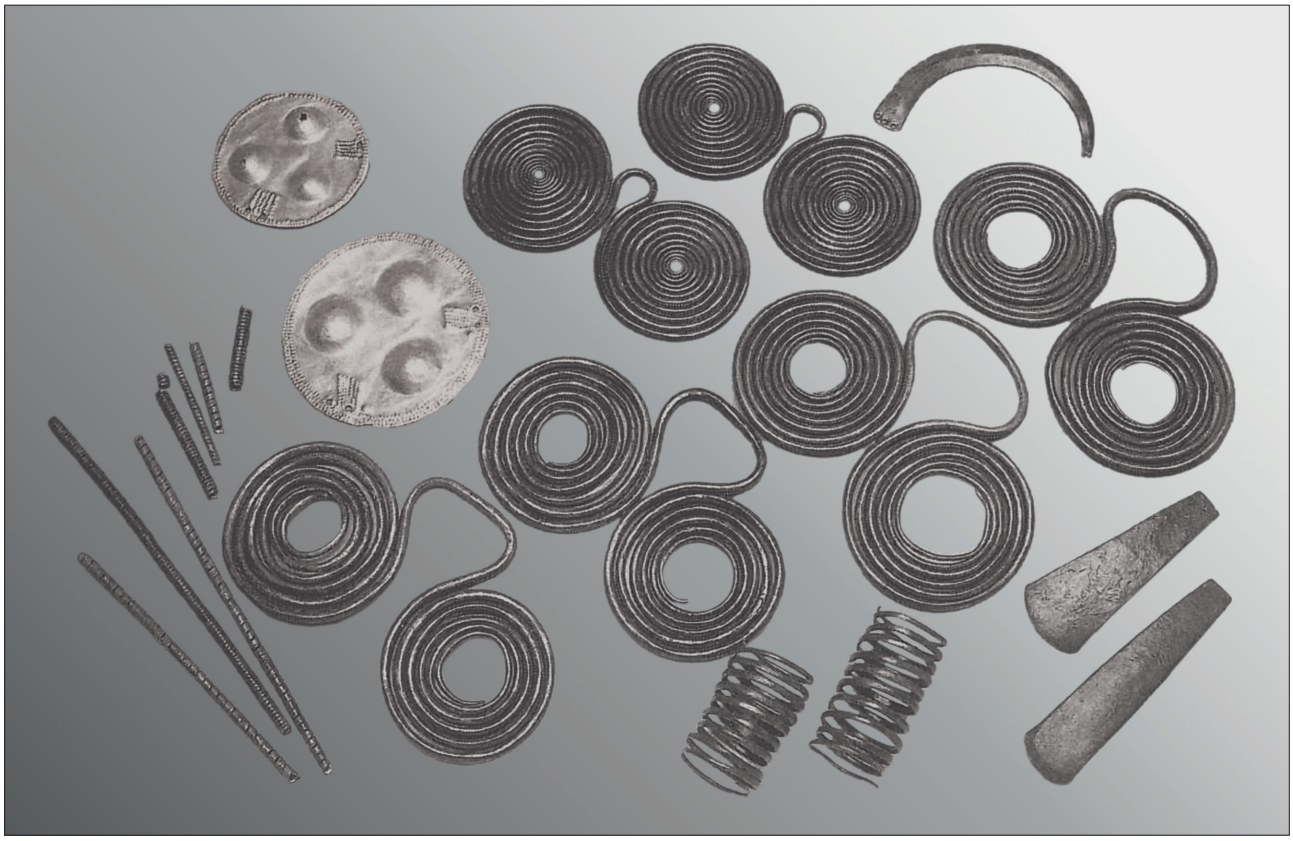


Fig. 26 The hoard of Stollhof, administrative district of Wiener Neustadt (Austria), can be dated to the last quarter of the 5th millennium. Four large golden spirals (Brillenspiralen) are lost; no scale.

Abb. 26 *Der Hortfund von Stollhof, Verwaltungsbezirk Wiener Neustadt (Österreich), lässt sich in das letzte Viertel des 5. Jts. datieren. Vier große goldene Brillenspiralen sind verschollen; o. M.*

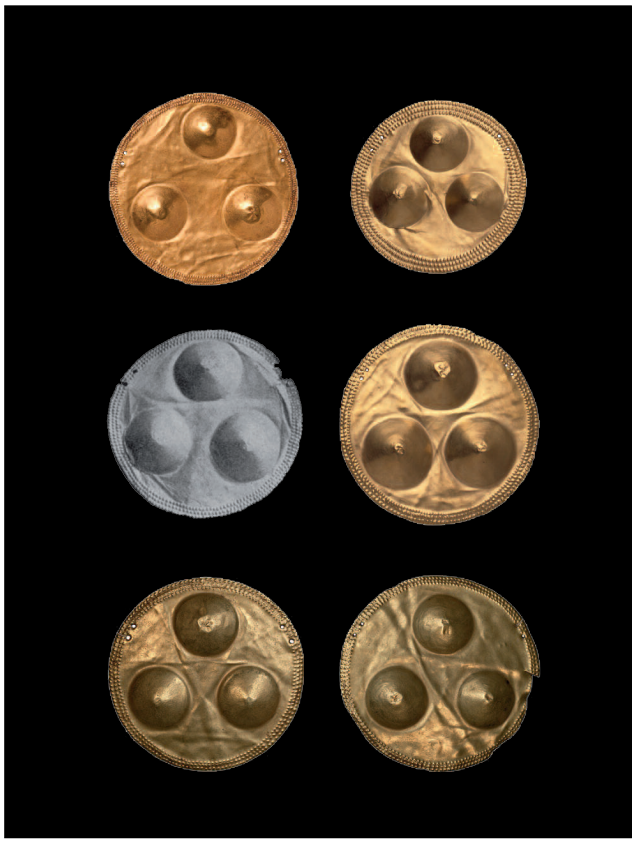


Fig. 27 The Tenja hoard at Osijek (Croatia) weighs more than 500 grams and dates between 4300 and 4000 BC.

Abb. 27 *Der Hort von Tenja bei Osijek (Eszék/Esseg) (Kroatien) wiegt mehr als 500 g und datiert zwischen 4300 und 4000 v. Chr.*

If one compares the number of axes in hoards, and of course also their weight, with Caucasian grave finds, the special nature of the deposition becomes even clearer. In the Caucasus, the deposition of one or two axes in the grave was linked to the ruling class. Actually, the number of excavated graves in the Caucasus with an axe as grave good is less than 20.

The problem of deposition

In general, the practice of deposition of metal objects as grave goods, whether in hoards or as single deposits, was the precondition for the survival of any metal objects in the archaeological record (Hansen 1994 for the methodology). There are practically no lost metal objects, at least no heavy axes or large daggers and swords. In general, metal objects were melted down and reused for new objects. What is left in the ground is just a selection from the former range of metal objects. This is not only made clear by the rules of metal deposition. It can also be understood from the example of stone moulds. For many stone moulds, there are no bronze products in the archaeological record.

The distribution map of a special type of object is therefore strictly speaking the map of the deposition of these objects. The same objects may also be used outside the regions where they were found. However, if they were not used there as grave goods or hoard items, this cannot be confirmed.

Sometimes it is obvious how deposition rules created the distribution of certain bronze types. One striking example are the late Middle Bronze Age swords with an octagonal metal grip. There are two distribution areas visible in the map (Fig. 25): southern Germany and northern Germany and Denmark. There is (with one exception) no sword of this type between the Main River in the South and the Region of Hamburg in the North. It is most probable that these swords existed also in the regions between but where not deposited. This was already the conclusion reached by Hans-Jürgen Eggers (1959, 287 f.). Many other examples can be added. Therefore, the distribution of a certain type of metal object with two isolated concentrations does not mean that they have nothing to do with each other. Research on hoards and river finds as offerings has been concentrated on the huge find material from the 2nd millennium BC in Central Europe (Hansen 1994).

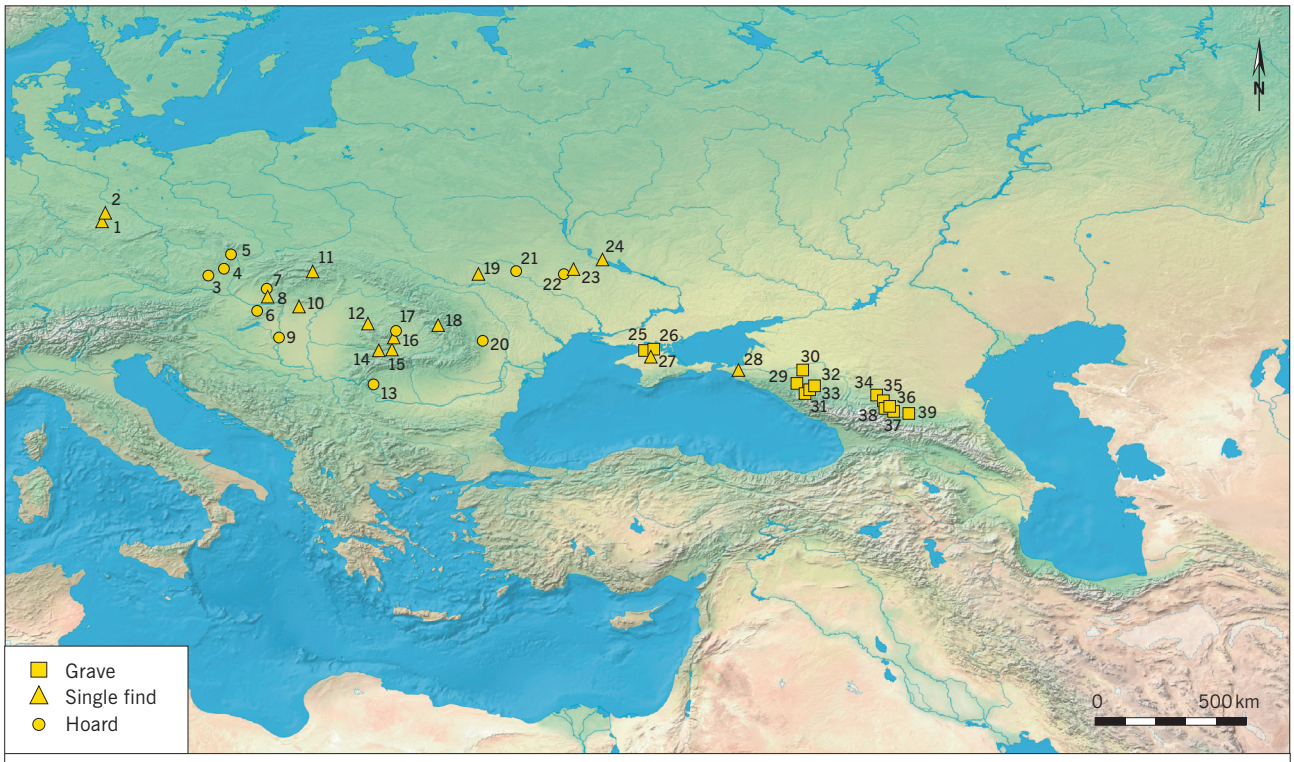
In the context of Copper Age archaeology, the research on rules of deposition (»Deponierungsregeln«) did not play an important role yet. The interpretation of hoards and single finds/depositions is unfortunately not well developed (Hansen 2009). In Copper Age archaeology, most of these hoards are simply considered as goods hidden in times of conflict. This is contradicted by the fact that there are rules governing the composition of the hoards. In the case of the shaft-hole axes, several types of hoards can be distinguished: the monotype hoard (Vâlcele, Žitavany, Kisbér), the complex tool hoard (Fajsz, Brno-Lišeň, Stavenice, Vevčice), and hoards such as Stollhof, which would be classified as complex hoards with weapons/tools and ornaments.

Stollhof, administrative district of Wiener Neustadt in Lower Austria, is an example of how hoards were laid down in »special places« and served as offerings to the spirits and gods (Angeli 1967) (Fig. 26). The *Hohe Wand* is a striking, steeply rising rock formation.

Another spectacular example for the deposition of hoards in the Carpathian Basin in Slavonia, dating to the late 5th millennium BC, is the hoard of Tenja (Croatia), which was found in a wet area near Osijek/Essek and contained six golden discs (Hansen 2014) (Fig. 27).

Late Neolithic/Copper Age Europe was interconnected in the 5th millennium BC through the exchange of goods, the mobility of people, and the spread of knowledge and ideologies. Many regions were linked by networks through which people, goods, and ideas circulated. These supraregional connections became even denser in the 4th millennium BC, and the interpretation of hoards should be a key for the understanding of these networks.

Therefore, it is not at all surprising that comparable ritual practices were gift exchange (Mauss 1968) exercised in many places, even those separated by great distances. Among such practices was the deposition of objects that were meant as gifts for the spirits or deities: in short, for all imagined powers. The presentation of gifts to these powers was made according to the principles of gift exchange that were adhered to in Neolithic and Bronze Age societies. By being given a gift, the recipient was obliged to reciprocate



1 Zscheiplitz
2 Brachwitz
3 Vevčice
4 Brno-Lišeň
5 Stavenice
6 Kisbér
7 Zitavany
8 Dolny Pial
9 Fajsz
10 Hatvan
11 Velky Slavkov
12 Vadul Crisului
13 Ostrovul Corbului
14 Hărău
15 Pianul de Sud
16 Coltes
17 Vâlcele
18 Toplita
19 Malievtsy
20 Corbasca
21 Ivonivka
22 Ivan'ky
23 Smilchintsy
24 Kedina Hora
25 Krasnoperekopsk
26 Dolinka
27 Steppe Krim
28 Chekon
29 Maikop
30 Vozdvishenskaya
31 Novosvobodnaja Kurgan 31
32 Novosvobodnaja (Tsarskaia)
33 Kostromskaja
34 Inozemčevo
35 Mar'inskaja 3
36 Čegem II
37 Nalčik
38 Kišpek
39 Zamankul

Fig. 28 Distribution of shaft hole axes.

Abb. 28 *Verbreitungskarte der Schaftlochäxte.*

with a counter service. Involvement in the cycle of gift-giving to the imagined powers was a matter of course in many ancient religions.

Tellingly, the deposition of hoards was never considered as a *longue durée*. In recent years, however, more and more research has been published in which the tradition of hoard deposition has been traced back to the Copper Age (Hansen 2019). Christian Jeunesse has emphasised the connections between the social practice of dumping and grave furnishings in the *longue durée* from the Neolithic to the Iron Age: »The hoard and elite grave system is established at the end of the early Neolithic. It functions as an ideological root which then conditions the functioning of late prehistoric societies up to the end of the 1st millennium AD. The development of states pushes it to the background of the historical stage, into a kind of ›collective subconscious‹, where it remains a powerful and devious opponent of the state logic. Its emergence is anything but a consequence of the invention and development of metallurgy, which is not a prerequisite, but a product of this system. Besides, metallurgy is at first only used to fuel the luxury economy generated by the ostentatious behaviours of local chieftains and the kings. Generally speaking, one could say that the existence of a king explains the invention of the lost wax technique in Varna or in the Maikop Culture and drives the processes that led to the erection of the Er Grah broken menhir at Locmariaquer, and certainly not the reverse« (Jeunesse 2017, 184).

This makes the burial of grave goods and the deposition of sacrificial hoards a structuring practice in the younger prehistory of Eurasia. There is a *mechanics* of deposition that varies from landscape to landscape. The individual actions when depositing metal objects are subject to these *mechanics*. In the North Caucasus, Vâlcele-Maikop shaft-hole axes were used as grave goods; in the Carpathian Basin and in the northern Black Sea region, they were part of hoards. The distribution map (Fig. 28) shows that the Dnipro River can be considered geographically as the boundary of the two different social practices, both belonging to the same sphere of offerings.

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Der soziale Wert prähistorischer Beile – neue archäologische und archäometrische Ansätze

The social value of prehistoric axes – new archaeological and archaeometric approaches

16. Mitteldeutscher Archäologentag
vom 5. bis 7. Oktober 2023 in Halle (Saale)
16th Archaeological Conference of Central Germany
October 5–7, 2023 in Halle (Saale)

Band 2

BRONZEZEIT

BRONZE AGE

In der gerippten »Doppelaxt« aus dem Hortfund Teicha I, Saalekreis, konnten noch Reste der hölzernen Schäftung nachgewiesen werden. Zusätzlich wurde das Schaftloch durch einen Nietkopf abgedeckt, sodass neben dem konstruktiven Nutzen auch eine ästhetische Komponente angenommen werden kann (s. Beitrag Bunnefeld u. a. in diesem Band).

In the ribbed »double axe« from the Teicha I hoard, Saalekreis district, traces of the wooden hafting could still be found. In addition, the shaft hole was covered by a rivet head, so that an aesthetic function can be assumed alongside the constructive benefit (cf. Bunnfeld et al. in this volume).

The use of axe- and ring-metal as a raw material source in the Late Neolithic and Early Bronze Age in Southern Scandinavia

Heide Wrobel Nørgaard

Zusammenfassung

Die Verwendung von Beil- und Ringmetall als Rohmaterialquelle im spätneolithischen und frühbronzezeitlichen Südskandinavien

Ein kontinuierlicher Anstieg des Metallflusses nach Südskandinavien beginnt um 2100–2000 v. Chr. Die ersten Netzwerke gewährleisteten die Versorgung mit Metallen aus dem österreichischen Inntal und der Slowakei, ergänzt durch zinnreiches britisches Metall. Diese Netzwerke veränderten sich im Laufe der nächsten 700 Jahre, verblassten und wurden teilweise durch neue Kontakte ersetzt. Einer dieser neuen Kontakte versorgte den Norden mit ostalpinem Metall vom Mitterberg und später mit Metall aus den südlichen Alpen, das ab der entwickelten nordischen Bronzezeit zur dominierenden Quelle wurde. Spuren eines Rohstoffhandels, sind hier in der frühen Bronzezeit Südskandinaviens nicht erkennbar. Auch Barren, wie man sie aus Süddeutschland kennt, sind in der frühen Bronzezeit selten Teil von Funden. Im Gegenteil scheint der gezielte Import von Artefakten mit bestimmten Materialeigenschaften die Grundlage für die lokale Materialproduktion zu sein. Axt- und Ringmetall wurden als Rohstoffquelle für die weitere Produktion nach Skandinavien gehandelt. Neben der eigentlichen Nutzung der Artefakte wurden große Mengen der Nutzung entzogen, um sie gezielt wiederzuverwenden. Die hochzinnhaltigen Bronzeäxte von den Britischen Inseln trugen wesentlich zur frühen Bronzeproduktion im Spätneolithikum in Südskandinavien bei. Zusammen mit großen Mengen an Äxten aus nickelreichem Fahlerz, die aus dem Aunjetitzer Gebiet importiert wurden, und Ringmetall aus nickelarmem Fahlerz aus den Zentralalpen bildeten sie die Materialbasis für die lokale Metallverarbeitung in den ersten 200 bis 300 Jahren der Nordischen Bronzezeit. Darüber hinaus könnte auch das Erscheinen der Speerspitzen in einer frühen Phase (BZ Periode IA; 1750/1700–1600 v. Chr.) ein Nebenprodukt des sich verändernden Metallhandels und des Zuflusses neuen Metalls in einen bestimmten Axttyp sein. Der metallurgische Fingerabdruck von Äxten des Virring-Typs und der frühesten Speerspitzen kann mit der lokalen Produktion mehrerer Artefakte mit ähnlichen südosteuropäischen Signaturen in Verbindung gebracht werden.

Schlagwörter Frühbronzezeit, Metallhandel, Artefakt-Währung, Archäometallurgie, Speerspitzen

Summary

A continuous rise in the flow of metals to Southern Scandinavia begins around 2100–2000 BC. The first networks established guaranteed a supply of metals from the Austrian Inn Valley and Slovakia, complemented by high-tin British metal. These networks shifted during the next 700 years: They faded out and were partially replaced by new contacts supplying the north with metal from the Eastern Alpine Mitterberg and, later, from the Southern Alpine region, which became the predominate source from the established Nordic Bronze Age onwards. No traces of a raw-material trade have been visible in Southern Scandinavia's Early Bronze Age periods, nor have deposits of ingots, as they are known from southern Germany, been discovered. On the contrary: The targeted import of artefacts with certain material properties seems to have been the basis for local material production. Axe- and ring-metal were traded to Scandinavia as a raw material source for further production. In addition to the actual use of the artefacts, large quantities had been withdrawn from use in order to be reused in a targeted manner. The high-tin bronze axes from the British Isles contributed significantly to the early production of bronze in the Late Neolithic in Southern Scandinavia. Together with the large quantities of axes made of Ni-fahlore imported from the Únětician region and the ring-metal of low-Ni-fahlore from the Central Alps, they form the material base for the local metalwork in the first 200 to 300 years of the Nordic Bronze Age. Additionally, the appearance of the spearheads in an early period of the Nordic Bronze Age (NBA IA 1750/1700–1600 BC) might also be the result of an influx of new metal in a specific axe type. The metallurgical fingerprint of Virring-type axes and the earliest spearheads can be related to the local production of several artefacts with similar South-Eastern European signatures.

Keywords Early Bronze Age, trade networks, artefact ingots, archaeometallurgy, spearheads

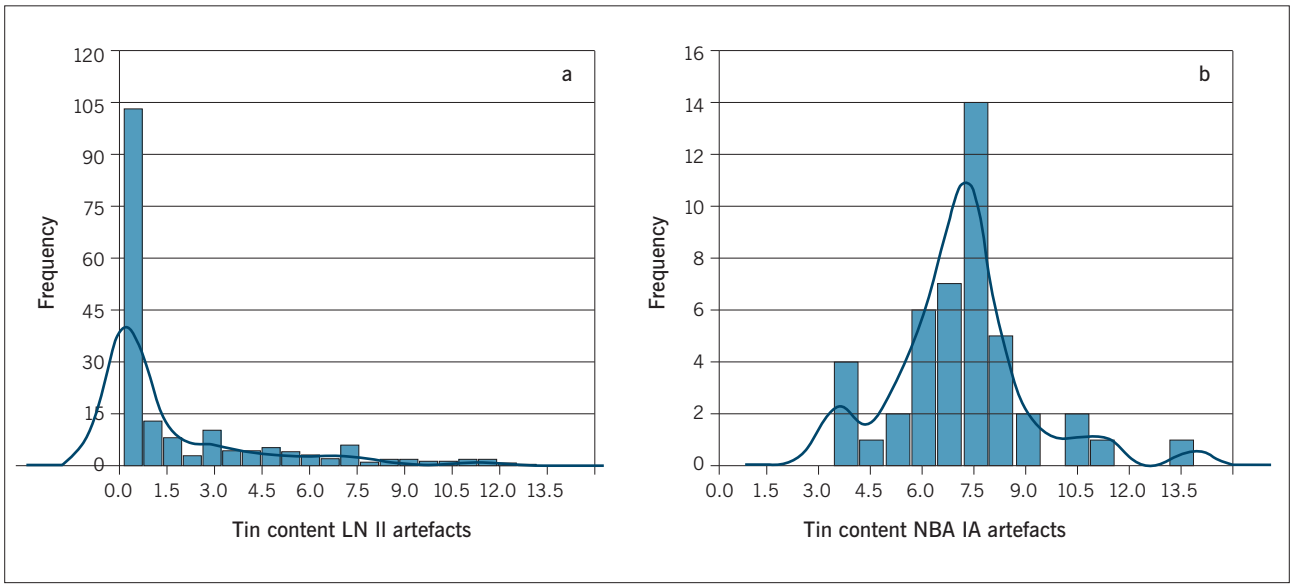

Fig. 1a–b Histogram of the tin percentage within LN II (a) and NBA IA (b) artefacts found in Denmark.

Abb. 1a–b *Histogramm des prozentualen Zinngehalts von Artefakten der Stufe II des Spätneolithikums (a) und Periode IA der Nordischen Bronzezeit (b) aus Dänemark.*

Introduction

Our knowledge concerning the metal trade networks that supplied the Scandinavian Bronze Age with the most needed raw material has grown immensely in the last decade. Several projects aimed to define possible supply centres, networks, routes, and shifts in time, by analysing artefacts regarding their archaeometallurgical fingerprint[1]. The number of analysed artefacts corresponds to around 50 % of the known metal artefacts from the establishment of the Nordic Bronze Age to its decline. Thus, the state-of-the-art knowledge provides an excellent base, allowing estimations on the extension of the defined networks and how this metal trade might have been organised. This article will focus on defining the kind of metal used within the trade to the outskirts of the metal-producing areas in the Bronze Age in Europe.

Today we know that the first 700 years of the Nordic Bronze Age (Fig. 1) have been characterised by a continuous rise in the flow of metals to Southern Scandinavia that began around 2100–2000 BC, with the hoard from Pile, Scania (Sweden), as one of the most characteristic finds

APPROX ^{14}C RANGE *	MAJOR DIVISION	AEGEAN	EUROPE NORTH OF ALPS	SOUTHERN SCANDINAVIA
3800–2900 BC			Neolithic Farmers	Earlier Neolithic
2900–2350 BC			Corded Ware	Younger Neolithic
2350–2100 BC			Bell Beaker	Late Neolithic I (LN I)
2100/2000–1700 BC	EBA	MH III	EBA (Br A1–2b)	Late Neolithic II (LN II)
1700–1600 BC		LH IA-B	Final EBA (Br A2c/A3)	NBA IA
1600–1500 BC		LH II	Early MBA (Br B1)	NBA IB
1500–1300 BC	MBA	LH IIIA-B	Late MBA (Br B2/C)	NBA II
1300–1200/1100 BC		LH IIIC	Final MBA/Early LBA (Br D–HA A)	NBA III

Tab. 1 State-of-the-art chronology of Southern Scandinavia and European-scale. * The ^{14}C ranges are based on a combination of radiocarbon and dendrochronological determinations.

Tab. 1 *Neueste chronologische Daten und Vergleich von Südskandinavien mit anderen Teilen Europas. * Die ^{14}C-Spannen beruhen auf einer Kombination von Radiokohlenstoff- und dendrochronologischen Bestimmungen.*

1 Nørgaard et al. 2019; Nørgaard et al. 2021; Nørgaard et al. 2022; Ling et al. 2014; Ling et al. 2019; Melheim 2015; Melheim et al. 2018; Melheim/Sand-Eriksen 2020; Vandkilde 2017.

(Vandkilde 2017). High impurity (fahlore) metal from the Austrian Inn Valley and Slovakia was among the first metals to arrive in Scandinavia, probably via the central German Únětician hubs. This fahlore metal was differentiated by low or high nickel (Ni) content, it originated in central Europe, and it is associated with a specific type of artefact: axes and loop neck-rings (Nørgaard et al. 2021). Complemented by high-tin British metal, these three sources represent the major metal suppliers in the Southern Scandinavian Late Neolithic (LN II), between 2000 and 1700/1750 BC (Tab. 1). During the first phase of the establishment of the Nordic Bronze Age (NBA IA, 1750/1700–1600 BC), instabilities that end in the Únětice downfall in c. 1600 BC might be responsible for a period of raw material shortage, visible in the reuse of existing stocks. The direct reaction to these changes is visible from 1600 to 1500 BC, i.e., within the NBA IB period, when the metal-supplying networks extended to the south. The material testifies that there was a continuing supply of low-impurity copper from the Slovakian area and Central Alpine metal was used in the creation of status symbols, such as the shaft-hole axes (Nørgaard et al. 2022). Additionally, an initial use of Northern Italian copper can be documented in NBA IB (1600–1500 BC), an extension of the network to the south which will dominate the metal trade in the following periods. English and Welsh metal played a central role during this period. Finally, from around 1500 BC, when British copper imports declined, the predominance of novel Northern Italian copper coincides with the full establishment of the NBA and highlights a western in-land route (Nørgaard et al. 2019; Nørgaard et al. 2021; Nørgaard et al. 2022) connecting the NBA with the Southern German ›Tumulus Culture‹ and the first transalpine amber traffic (Vandkilde et al. 2024).

As the metal networks providing the NBA's most-needed raw material were subject to change, the material culture was likewise changing with the development of the Nordic Bronze Age. While the Late Neolithic (LN) II period was characterised by a predominance of flat and, later, flanged axes and ring metal, the beginning of NBA IA can be connected to the appearance of a new artefact type: the spearhead (Vandkilde 1996). In the following period, NBA IB, the sword also gained its place in the material culture repertoire (Berger et al. 2022), showing undoubted connections to South-Eastern Europe.

The above-mentioned studies of H. W. Nørgaard and colleagues suggested that certain artefacts function as ingots within the metal trade (Nørgaard et al. 2019; Nørgaard et al. 2021). Despite earlier assumptions of a raw material trade, no trace of it has been visible in Southern Scandinavia's Early Bronze Age periods. Additionally, the deposition of ingots in a manner comparable to the deposition of rib- or ring-ingots during the Early Bronze Age in Central and Southern Germany is unknown in Southern Scandinavia. Ingots appear in Scandinavia in hoards first in the Late Bronze Age, around 1000 BC. Here, casting cakes, metallurgical debris, and partly broken pieces of bun ingots of bronze and tin (see Boddum et al. 2011; Boddum et al. 2015) testify to an emerging hoarding tradition connected to metallurgical activities. However, the targeted import of artefacts with certain material properties seems to be the basis for local material production in the Early Nordic Bronze Age.

Early tin bronze in Southern Scandinavia

From a bird's-eye view, it is astonishing that Southern Scandinavia fully joined the group of metal-using societies only at the dawn of the 2nd millennium BC (Nørgaard et al. 2019; Vandkilde 2017). What is particularly interesting here is the way in which it was done. Imported metal artefacts have been known since the 5th millennium BC in Southern Scandinavia (Klassen 2000; Klassen 2004), and, already at this stage, different metal sources were used (Nørgaard et al. 2021, 9; Brozio et al. 2023). Denmark might have had an independent metal production already in the 3rd millennium BC (Gebauer et al. 2020), but the earliest clear evidence for local metal production in Southern Scandinavia dates to the beginning of the 2nd millennium BC (i.e., Vandkilde 2017). In contrast to many metal-using societies, this change in material culture did not take place in stages of development – as observed in the south (from pure copper to fahlore to bronze) – but rather in a rapid development from the import of artefacts to the parallel local production of copper and tin-bronze and the exclusive production of tin-bronze objects.

This rapid introduction of tin-bronze (Fig. 1) is likely connected to the way in which metal as raw material was imported.

The Southern Scandinavian Late Neolithic material culture is characterised by a variety of imported artefact types, predominately axes and ring-shaped items (see Vandkilde 1996). Moreover, Southern Scandinavia is the continental region with the largest number of Anglo-Irish axe-heads outside of the British Isles, followed by the Rhine estuary and the middle Elbe region (Fig. 2). Anglo-Irish axes[2] appear first in Scandinavia in the early LN II with single specimens of the Killaha-type (i.e., Harbison 1969). The numbers increased in the second part of LN II, and developed flat axes appeared in single depositions in bogs, burials, and hoards (i.e., Burgess/Schmidt 1981; Harbison 1969). The distribution of these axes outside the British Isles suggests a transport route along the coast (Butler 1996; Needham 2009) with further inland travel through river systems. Evidence of axe-hack metal[3] and amber axe-pendants imitating decorated flat axes in the Limfjord region in Northern Jutland (see Vandkilde et al. 2024), in addition to hot spot centres for Baltic Amber in Únětician hubs (Vandkilde 2017), support the importance of this route.

However, the preserved axes of Southern Scandinavia are of extraordinary shape and size (see Butler 1955). As

2 See Harbison 1968; Harbison 1969; Megaw/Hardy 1938; Needham 1983; Vandkilde 1996; Burgess/Schmidt 1981.

3 Two halves of developed undecorated flat axes similar to the Ballyvalley-type from the find location Limfjord, North Jutland (Denmark), are known from the collections of the British Museum (<https://www.britishmuseum.org/collection/object/H_1869-0724-1> [08.04.2024]), indicating the presence of broken axe metal.

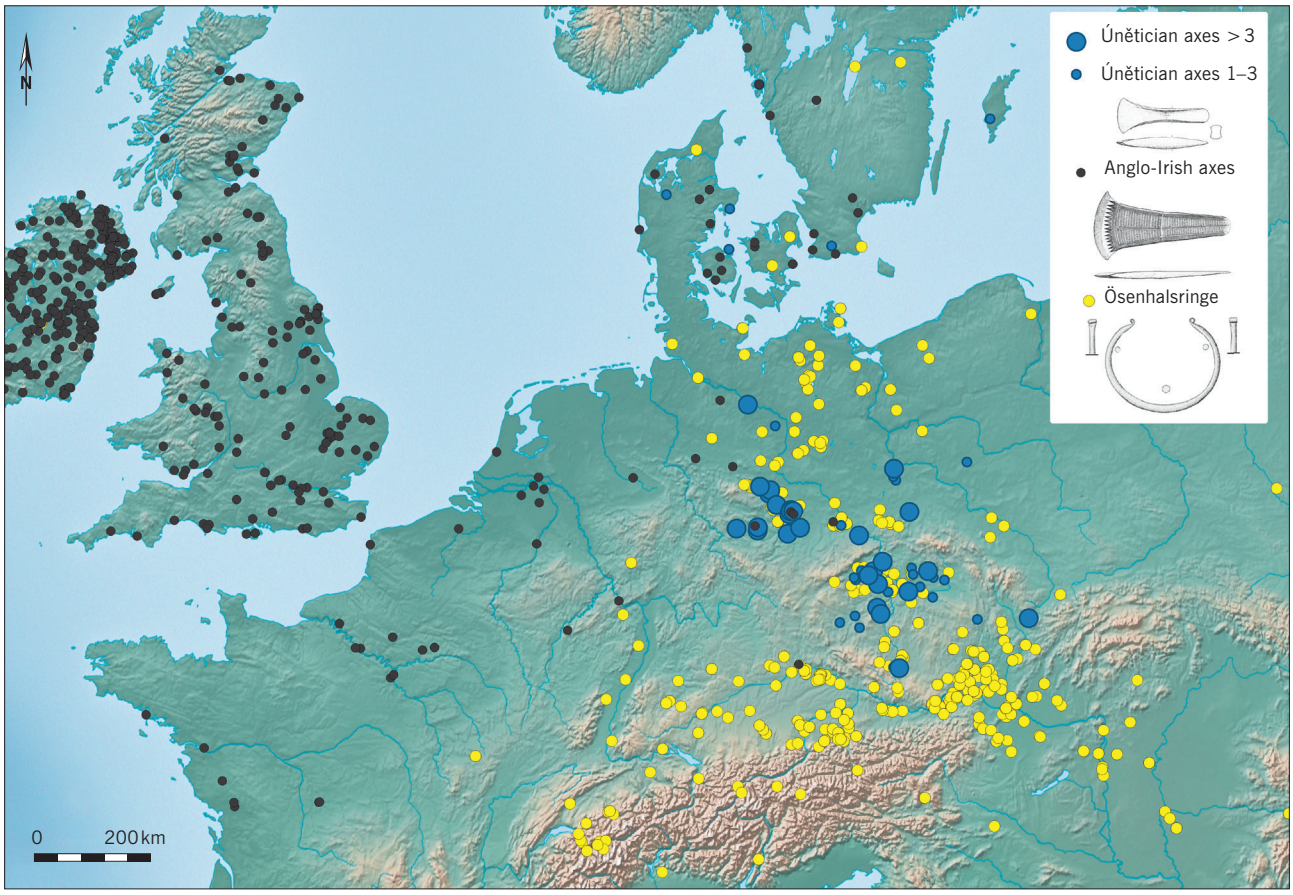

Fig. 2 Distribution of the artefacts that are considered the major sources of metal for the Southern Scandinavian Late Neolithic (LN II) and earliest Bronze Age (NBA IA): the Anglo-Irish axes, Úněticiaan flange axes, and looped neck-rings *(Ösenhalsringe)* in Central and Northern Europe. The distribution of Anglo-Irish axes in France and Belgium is still an ongoing task and the present map does not consider the latest publications by H. Gandois.

Abb. 2 *Verbreitungskarte der Artefakte, die als wichtigste Metallquellen für Südskandinavien während des Spätneolithikums Stufe II und der Nordischen Bronzezeit Periode IA gelten: anglo-irische Beile, Randleistenbeile der Aunjetitzer Kultur und Ösenhalsringe in Mittel- und Nordeuropa. Die Kartierung der anglo-irischen Beile in Frankreich und Belgien ist noch nicht abgeschlossen; ebenso sind die jüngsten Veröffentlichungen von H. Gandois unberücksichtigt.*

such, it seems that besides the preserved high-quality axes, British artefacts were reused within the Southern Scandinavian metal production. An intensive typological examination of the 150 analysed LN II axes (i.e., Nørgaard et al. 2019; Nørgaard et al. 2019a; Nørgaard et al. 2021) illuminates the origin of the tin detected in the Scandinavian artefacts (Fig. 3).

Especially the larger local axe types (A3 and A4 in Vandkilde 1996, 66–91) show tin contents far over the 2 % hurdle that was considered the minimum required for an alloy to be called bronze, as determined in the 1990s through extensive studies of early copper alloys (i.e., Muhly 1993, 240)[4]. The axes with the highest tin content – above 7 wt % and up to 14 wt % – are classified as of Anglo-Irish origin and show the expected high-tin bronze. This uneven distribution of the tin content in these early bronzes indicates an intentional reuse of foreign artefacts to create local objects.

It seems that especially British metal has been of interest for the production of local axe types. Some axes indicate a direct recast of Anglo-Irish axes to local forms such as the large Storre-Heddinge-type axe from Ørnbølle Hede (NM 26062; Vandkilde 1996, 422) and the nearly 12-cm-long Gallemose-type axe from Northern Jutland (ÅHM 3384, Vandkilde 1996, 416.) with 10.4 and 11.3 % tin (see Fig. 3). Other artefacts point towards a potential mixing of high-tin bronze with low-tin copper artefacts.

The well-known hoard from Store-Heddinge near Præstø on Zealand (Denmark) can shed light on this reuse of British axe metal in local Southern Scandinavian metal production. First and foremost, a detailed isotopic investigation revealed that the Anglo-Irish axe types were imported to Southern Scandinavia and that the metal assumed to be reused in local production had been made solely from English and Welsh metal deposits (see Nørgaard et al. 2019; Nørgaard et

4 Copper ore can have varying concentrations of tin as a trace element, mostly in the ppm range. However, occasionally deposits can contain copper and tin in the ore mineral, as the example of the Mushiston mine, Sughd Region, in Tajikistan shows (see Berger et al. 2023). The metal smelted from this kind of ore will have varying concentrations of tin. The 2 % hurdle that Muhly mentions is based on the distribution of tin contents in Early Bronze Age archaeological objects (see here also data from the Stuttgarter Metallanalysendatenbank, Junghans et al. 1960; Junghans et al. 1968; Junghans et al. 1974; Krause 2003). Nevertheless, new experiments on the impact of trace elements in copper alloys have shown that significant visual changes of the alloy first occur at a proportion of at least 2 % (Mödlinger et al. 2017).

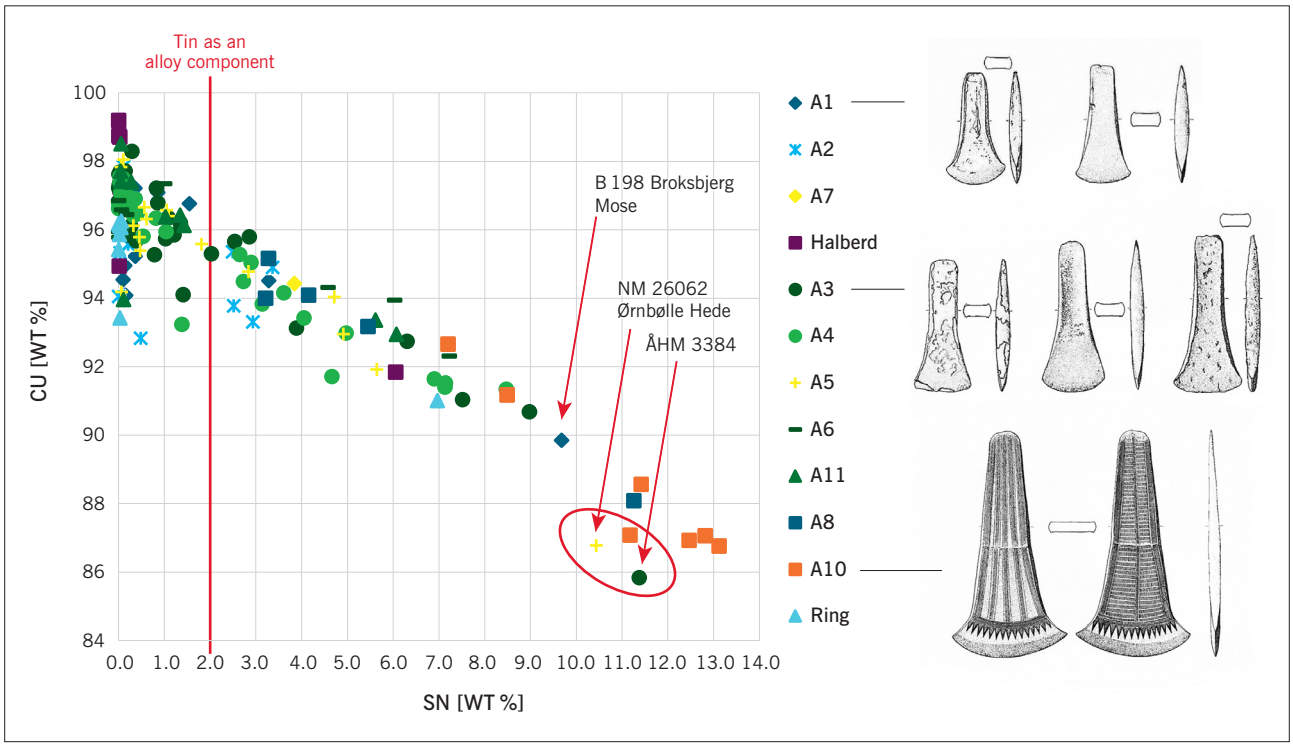

Fig. 3 Tin concentrations in LN II artefacts, taking into account the identified stylistic types. The typological classification is based on H. Vandkilde 1996.

Abb. 3 *Zinngehalt von Artefakten der spätneolithischen Periode II unter Berücksichtigung der typologischen Einteilung nach H. Vandkilde 1996.*

al. 2021). It follows that the axes should be referred to as Anglo-type axes. Second, a typologically identified Anglo-type axe is not *per se* of English or Welsh metal. For example, the large axe with narrow waist and ›English‹ bevelled decoration from Tolne Hjorring in Northern Jutland (NM3887; Tab. 2) cannot be isotopically associated with British ores even if the chemical composition is comparable with the low impurity copper known to be from English and Welsh sources (see Nørgaard et al. 2019, 21).

The Store-Heddinge hoard contains four axes: one decorated Anglo-flanged-axe (MLXIX), two primitive flanged axes with strong typological characteristics of Anglo-axes (MLXXa–b), and a local-style flanged axe of the Store-Heddinge-type MLXXc (Fig. 4; Tab. 2; according to Vandkilde 1996, 80). The isotopic ratios of the axes reveal that the large decorated piece MLXIX was made of Welsh or English metal. The same is valid for the local-style axe MLXXc, which has a tin content of 6.9 wt % (Fig. 5). The two primitive flanged axes MLXXa and MLXXb are stylistically very similar. While MLXXa is very likely made of metal from the Alderly Edge mine in England; the other axe seems to be a product of mixing British and Slovakian artefact metal in an attempt to copy foreign styles. Table 2 presents several artefacts that can be typologically considered as hybrid forms, stylistically between the characteristic long narrow shape and flattened flanges of Anglo-type axes and the partly high-flanged curved axes of local style (typology based on Vandkilde 1996). They provide the basis for the isotopic investigation visualised in Fig. 5. Interestingly, the large decorated local-style axes are frequently produced with metal from Welsh or English sources[5].

In addition to the tin values and isotope ratios of Anglo-type axes presented above, further evidence of possible mixing of artefact metal in local production can be referred to. As suggested by the examined imported artefact types (see Fig. 2) and the concentration of Baltic amber finds in the circum-Harz region, an intensive exchange of goods is to be expected between the Southern Scandinavian and the Únětice region. The studies by Nørgaard and colleagues (2019; 2021), which include around 600 artefacts from the first 600 years of the Nordic Bronze Age, revealed that two dominant fahlore types supplied the Late Neolithic and Early Bronze communities in Denmark with copper. The nickel-rich fahlore probably had its origin in the Slovakian Ore Mountains (Nørgaard et al. 2019) and was used for making a variety of Únětician axe types. According to H. Vandkilde, Únětician axes provide a large proportion of the imported items (Vandkilde 2017, 147). The low-Ni fahlore could be linked to the mineral deposits in the Inn Valley (Nørgaard et al. 2021). This metal is also known as *Ösenring*-metal, as it is most widely used in looped neck-rings and only occasionally appears in the material culture of the Late Neolithic in Southern Scandinavia as complete items (see Fig. 2; cf. Vandkilde 2005).

5 Fig. 6 shows that especially the Gallemose axes (CM 142, B294), but also axes of type Store-Heddinge (MLXXc), Vaerslev (VMÅ139), and Æbelnæs (B10789 and B494), are predominately of Welsh metal. It shall be the task of future studies to clarify whether the Anglo-style axes ML6573 and ML6574 may also be local imitations of a popular form as they are probably made from Mitterberg copper.

Original no. A-number	Object	Date	Site	Context	Additional finds	Reference	Analyses
ML6574 MA-181036	flanged axe, type Anglo-Irisch A10	LN II	Beddinge, Vermenhögs, Scania	one-type hoard	similar flanged axe	Oldeberg 1974, 66	Nørgaard et al. 2019, S2
ML6573 MA-181035	flanged axe, type Anglo-Irisch A10		Beddinge, Vermenhögs, Scania	one-type hoard	similar flanged axe		
NM B294 MA-171110	flanged axe, type Gallemose		Brandslund, Skovby, Odense	single find, field	none	Vandkilde 1996, 414	
NM B198 MA-166631	flanged axe, type Emmen		Brokbjerg Mose, Hellum, Ålborg	single find, bog	none	Vandkilde 1996, 410	
ÅHM 3384 MA-171125	flanged axe, type Gallemose		Denmark	unknown	unknown	Vandkilde 1996, 416	
NM MA-170414	flanged axe, type Virring		Denmark	unknown	unknown		
VMÅ139 MA-171127	flanged axe, type Vaerslev		Dybvad Mølle, Års, Ålborg	single find, gravel	none	Vandkilde 1996, 418	
NM B1335 MA-166635	flanged axe, type Torsted-Tinsdahl		Flemløse, Baag, Odense	single find, gravel	none	Vandkilde 1996, 427	
NM 26063 MA-180953	flanged axe, type Anglo-Irisch A8		Flenstofte, Baag, Odense	single find, bog	none	Vandkilde 1996, 424	
NM B3888a MA-171133	flanged axe, type Anglo-Irisch A8		Gallemose, Støvring, Randers	multi-type hoard, bog	6 local flanged axes, 1 Únětician type axe, 7 solid rings, 2 ›Blutegel‹ rings, 3 hooks	Vandkilde 1996, 416	
NM3887 MA-170358	flanged axe		Hjørring, Tolne, Horns	burial in barrow	unknown	Vandkilde 1996, 421	
ML11056 MA-181037	flanged axe, type Anglo-Irisch A10		Löddeköpinge, Harjagers, Scania	single find	none	Oldeberg 1974, 72	
NM B10789 MA-170385	flanged axe, type Aebelnaes		Odsherred, Holbæk	one-type hoard	2 European-type flanged axes	Vandkilde 1996, 409	
NM B9819 MA-166625	flanged axe, type Store-Heddinge		Rye, Volborg, København	single find, meadow	none	Vandkilde 1996, 421	
NM B5310 MA-180951	flanged axe, type Anglo-Irisch A10		Selchausdal, Løve, Holbæk	single find, bog	none	Vandkilde 1996, 425	Nørgaard et al. 2021, S2
NM 4558 MA-180952	flanged axe, type Anglo-Irisch A8		Selchausdal, Løve, Holbæk	single find, meadow	none	Vandkilde 1996, 424	
CM 142 MA-171107	flanged axe, type Gallemose		Skibby, Horns, Frederiksborg	single find	none	Vandkilde 1996, 412	Nørgaard et al. 2019, S2
SØM3197 MA-171115	flanged axe, type Gallemose		Skodsbøl, Nybøl, Sønderborg	one-type hoard, near settlement	1 local-type flanged axe	Vandkilde 1996, 414	
MLXIX MA-180954	flanged axe, type Anglo-Irisch A10		Store-Heddinge, Stevens, Præstø	one-type hoard	1 local-type flanged axe, 2 Anglo flanged axes	Vandkilde 1996, 421	Nørgaard et al. 2021, S2
MLXXa MA-180955	flanged axe, type Anglo-Irisch A8		Store-Heddinge, Stevens, Præstø	one-type hoard			
MLXXb MA-180956	flanged axe, type Anglo-Irisch A8		Store-Heddinge, Stevens, Præstø	one-type hoard			
MLXXc MA-180957	flanged axe, type Store-Heddinge		Store-Heddinge, Stevens, Præstø	one-type hoard			
VHM 5384 MA-171122	flanged axe, type Aebelnaes		Tolne Parish, Horns, Hjørring	single find	none	Vandkilde 1996, 425	Nørgaard et al. 2019, S2
NM B3370 MA-170348	flanged axe, type Værslev		Valore, Ramsø, København	single find, field	none	Vandkilde 1996, 418	Nørgaard et al. 2021, S2
NM B494 MA-171063	flanged axe, type Æbelnæs		Æbelnæs, Mønbo, Præstø	single find	none	Vandkilde 1996, 423	
NM 26062 MA-170374	flanged axe, type Store-Heddinge		Ørnbølle Hede, Vennebjerg, Hjørring	burial in barrow	unknown	Vandkilde 1996, 422	Nørgaard et al. 2019, S2

Tab. 2 The artefacts with stylistic elements of Anglo-axes during LN II in Southern Scandinavia. The table gives context information (including original references), accompanying finds, and the reference to the open-access analytical data. Axe typology based on H. Vandkilde 1996.

Tab. 2 *Artefakte mit Stilelementen britischer Beile aus dem Spätneolithikum Stufe II in Südskandinavien. Die Tabelle enthält Befundinformationen (einschließlich Originalliteratur), vergesellschaftete Funde und den Verweis auf frei zugängliche Analysedaten. Typologie der Beile nach H. Vandkilde 1996.*

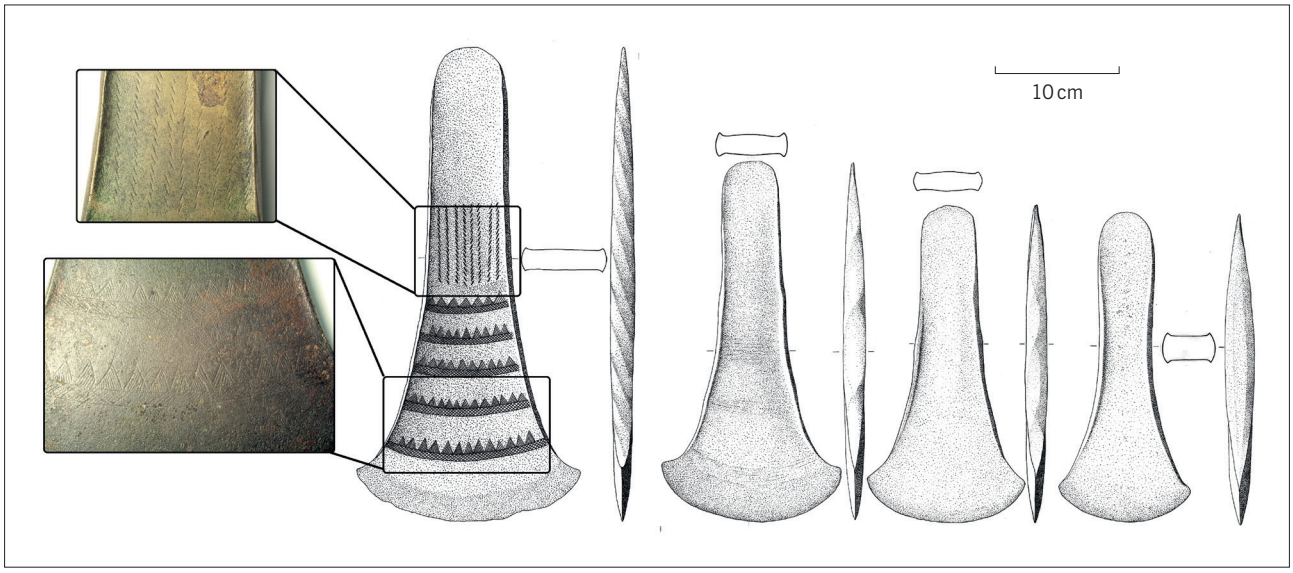

Fig. 4 The axes of the Store-Heddinge, Præstø (Denmark), hoard with details of the decoration of the Anglo-type axe MLXIX.

Abb. 4 *Die Beile des Horts von Store Heddinge, Præstø (Dänemark), mit den Verzierungsdetails auf Beil MLXIX vom Britischen Typ.*

Inspired by the composition of the Pile hoard (see Vandkilde 2017), which contains all potential metal types for the production of local Southern Scandinavian metal objects, the Danish metal objects from 2100/2000–1600 BC have been compared regarding their trace elements. The PCA (Fig. 6) clearly demonstrates the separation of ring metal and axe metal regarding the Ni content (see Nørgaard et al. 2019, 15). A definitive indication for the reuse of ring metal in local metal production is the appearance of local-style axes made of ring metal. The recast of Únětician axes with high Ni-content into local axe styles illustrates the reuse of these artefacts in local production. The comparable chemical fingerprint of local-style and Anglo-axes indicates a direct recast into local forms. The decrease in the tin content and the trace element concentrations could indicate a repetitive process or the mixing of different sources with strong differences in the trace element values (low-Ni fahlore vs high-Ni fahl-

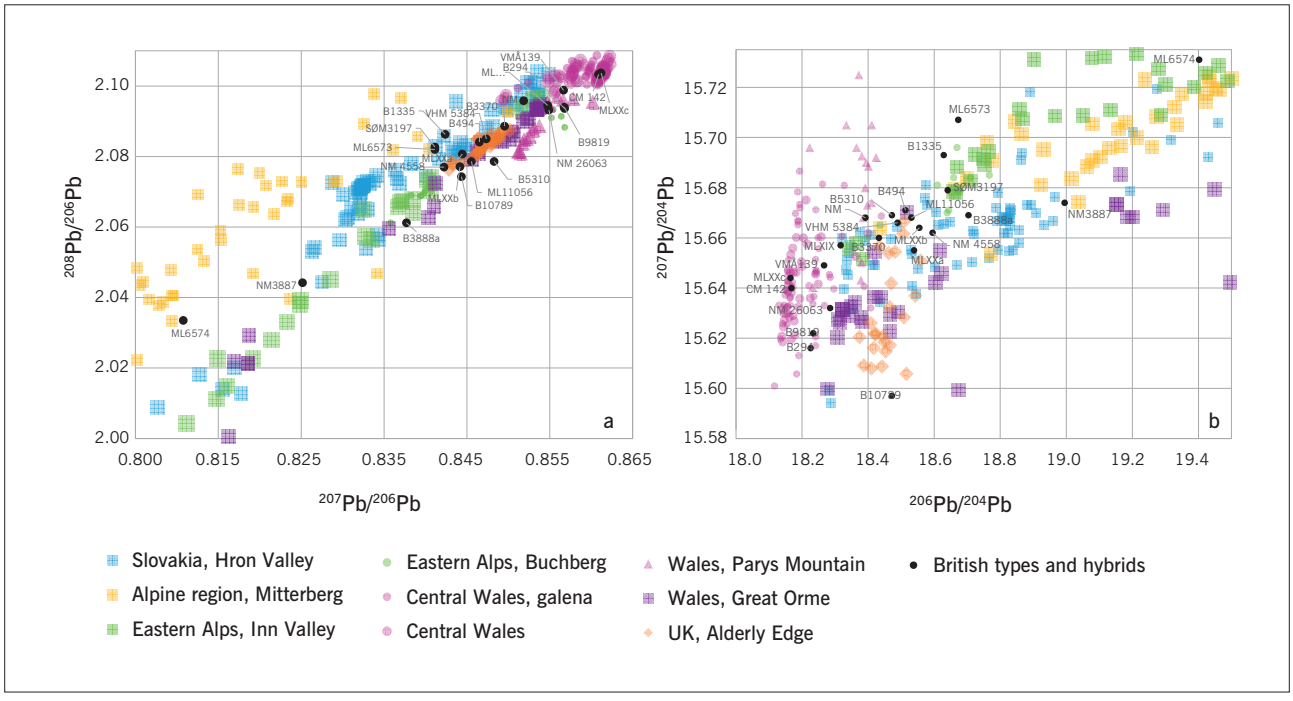

Fig. 5a–b Lead isotope ratios of artefacts that can be typologically described as hybrids and locally crafted artefacts made of low-impurity copper where a English/Welsh origin can be assumed.

Abb. 5a–b *Bleiisotopenverhältnisse in Artefakten, die typologisch als Hybride bezeichnet werden können, und in lokal hergestellten Artefakten aus Kupfer mit niedrigem Verunreinigungsgehalt, bei denen eine englische/walisische Herkunft angenommen werden kann.*

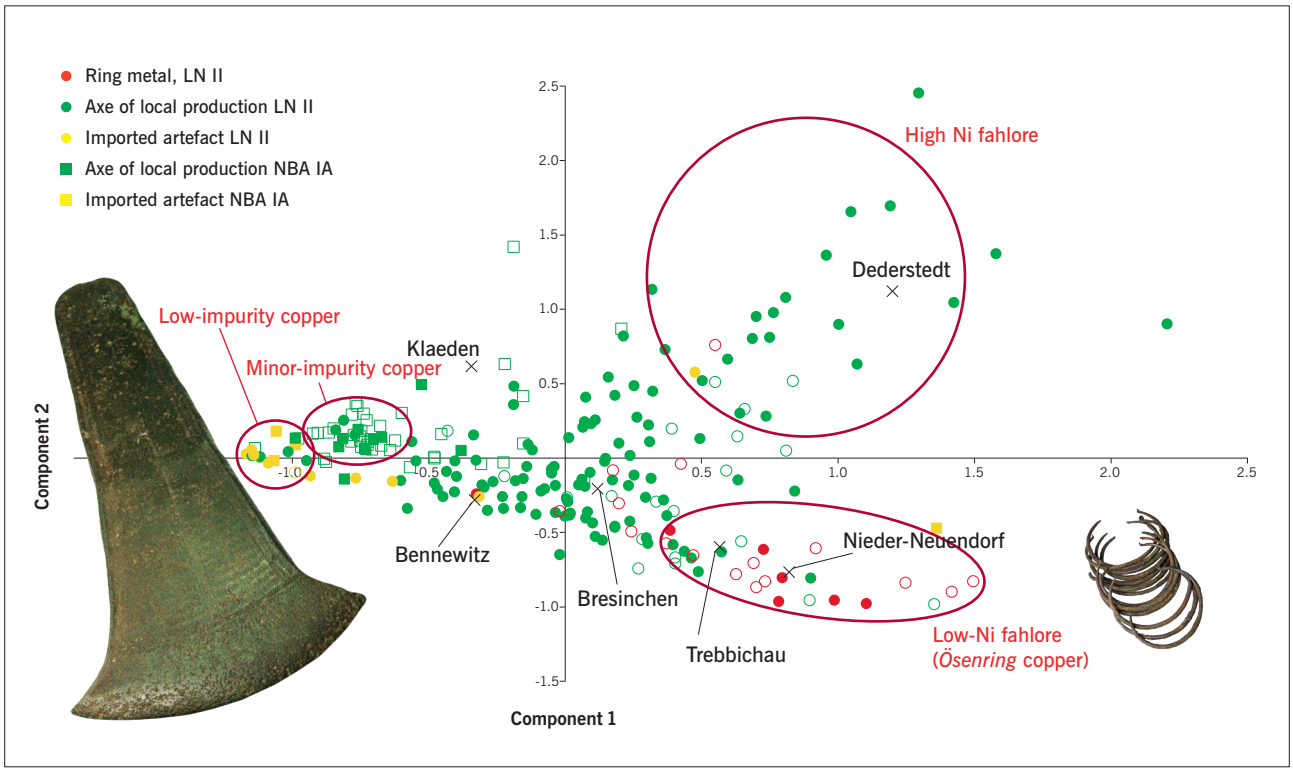

Fig. 6 Principal Component Analysis of the main trace elements (Ni, Sb, Ag, As) of the LN II (dots) and NBA IA (squares) artefacts from Denmark, including the LN II Pile hoard, Scania (Sweden). Colours indicate the artefact category, the data set of Pile (based on Vandkilde 2017) is highlighted with open symbols. The extended data set is compared with the median values for copper types (black X) defined by K. Rassmann (2005; 2010).

Abb. 6 *Hauptkomponentenanalyse der wichtigsten Spurenelemente (Ni, Sb, Ag, As) der in Dänemark gefundenen Artefakte aus dem Spätneolithikum Stufe II (Kreise) und der Nordischen Bronzezeit Periode IA (Quadrate), einschließlich des Depots von Pile, Skåne (Schweden), aus dem Spätneolithikum Stufe II. Die Farben geben die Art des Artefakts an. Die Daten der Funde aus Pile (nach Vandkilde 2017) sind mit ungefüllten Symbolen angegeben. Der erweiterte Datensatz wird mit den von K. Rassmann (2005; 2010) definierten Medianwerten für Kupfertypen verglichen (schwarzes X).*

ore). As the majority of the locally produced axes cannot be allocated clearly to one of the source metals, we need to assume, as already shown with the Store-Heddinge axes, that different artefact metals were mixed to achieve the right composition, colour, and hardness in the new artefact. The material properties of the desired metal are visualised in the object. Neck-rings symbolise a material that can withstand stress, and axes indicate a hard, resilient material. Colour differences may have been the main reason for the import of the high-tin bronzes from the British Isles but can be neglected when distinguishing the neck-ring copper from the axe copper. Even if nickel is also responsible for colour change in bronze, a visual effect would have been first achieved at a concentration above 2 wt % (see Mödlinger et al. 2017).

Thus, in the earliest stages of the Nordic Bronze Age, three main sources of metal paved the way towards the established Bronze Age: axes imported from the Únětician region and the British Isles and rings that originated in central Europe. The high-tin content in the Anglo-axes is responsible for the rapid adoption of bronze already in LN II. The mixing of high-Ni and low-Ni fahlores, both recognisable and separable by local metalworkers due to their visual differences, result in a high-impurity metal with a nickel content which is not known from ore bodies (see Nørgaard et al. 2019; Nørgaard et al. 2021).

Of axes, spearheads and swords

The intensive examination of the metal flow to Southern Scandinavia revealed that the first Bronze Age period (NBA IA, c. 1700–1600 BC) is characterised by the full implementation of bronze and probably the recycling of metal from the previous period (locally produced artefacts) as well as smaller amounts of incoming metal from sources and networks already used in LN II (Nørgaard et al. 2019, 24). It seems that this period is all about restructuring. A few centuries before, around 1750 BC, the classic phase of the Únětician Culture in Bohemia came to an end (Meller 2017, 1535). Baltic amber, which had been the major exchange good for the desired metal, was no longer omnipresent in the Únětician graves, and the shift of the rich amber burials towards the Mad'arovce-Větěrov cultural complex in the Northern Carpathian Basin (according to Ernée 2013; Meller 2017; Vandkilde et al. 2024) suggest a reconstruction of exchange networks.

Similar changes are visible in the material culture of the rising Bronze Age. From a bird's-eye-view, the finite chronological periods established for the Early Nordic Bronze Age (see Vandkilde 1989, Tab. 1) are characterised by a specific repertoire of tools and weapons. In Late Neolithic Denmark, axes, daggers, and halberds dominate (see Vandkilde 1993), whereas, in NBA IA, large hoards contain flanged axes combined with the earliest spearheads. In NBA IB, the earliest

swords appear. The changes in material culture in NBA IA are of specific interest to this study.

The NBA IA hoards of Bondesgårde near Torsted, Virring ved Randers, and Åbjerg near Ringkøbing in Central Jutland (Denmark; Fig. 7) exemplify the emerging custom of depositing partly vast sets of weapons. All these depositions contain a very specific local-style axe with a distinctly protruding cutting edge (the Virring-type axes) and socketed spearheads of Bagterp-type, variant Torsted (according to Vandkilde 1996, 101). The majority of these axes[6] have trace-element compositions showing high impurities, which, however, differ from the previously known metal sources. Some reflect the known fahlore-type metals common in LN II (based on Nørgaard et al. 2019).

Within the group of analysed artefacts one can find the complete inventory of the Virring depot from Central Jutland (Tab. 3; Fig. 7), which consists of a large flanged axe of Virring-type, a smaller axe of Torsted-type, three spearheads, variant Torsted, and a large decorated Central European spearhead (see Vandkilde 1996, 98). The metal of the Virring axe (B3962) from the eponymous depot and two of its spearheads (B3959, B3960) in the ^{206}Pb and ^{204}Pb isotope plot, could be allocated to South-Eastern European metal deposits, presumably from Serbian/Bulgarian mines[7]. In a thorough investigation of the remaining artefacts, two other Virring-type axes can be assigned to similar sources: the axes from Kragebæk (NM 21075), Holbæk, and from Ejstrup Holm (B108), Skanderborg (see Fig. 8). This evidence lends credence to the assumption that the appearance of Virring-type axes and spearheads is connected.

Assuming that a specific artefact, imported via a new connection, had entered the local metal pool, this new metal could have initiated the production of Virring axes. Some detected facts support this hypothesis. The majority of Virring axes plot in a very restricted space between a $^{206}Pb/^{204}Pb$ ratio of 18.80–18.95, a $^{207}Pb/^{204}Pb$ ratio of 15.645–15.665, and a $^{208}Pb/^{204}Pb$ ratio of 38.7–38.8. Half of the analysed socketed spearheads of the Torsted variant also plot here (Fig. 8). Interestingly, none of the known metal deposits in Europe match these ratios, and thus these values might have resulted from mixing. This would also mean that the »raw« materials used in producing Virring axes and spearheads are the same, if not that they were manufactured in a timely manner. Figure 9 illus-

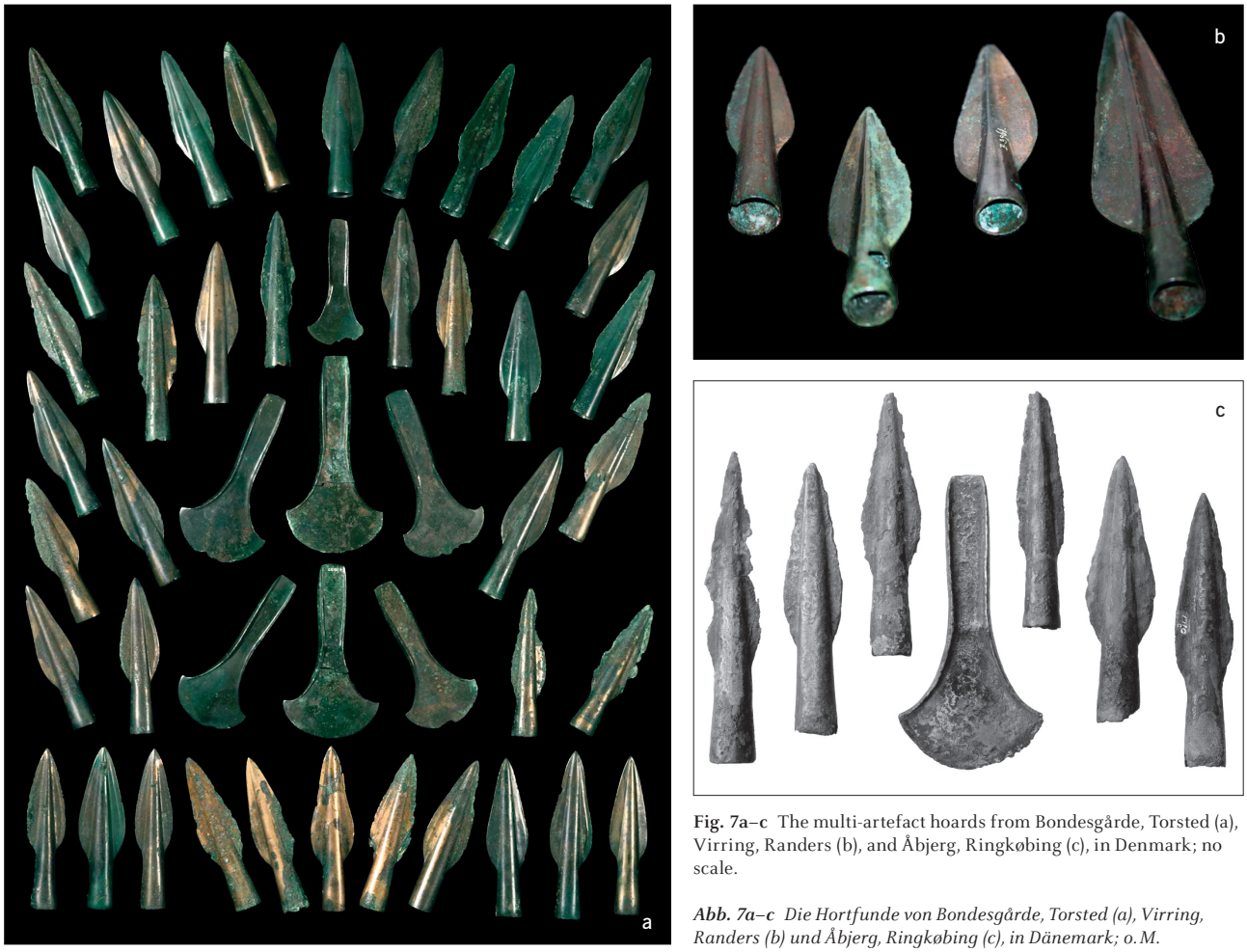

Fig. 7a–c The multi-artefact hoards from Bondesgårde, Torsted (a), Virring, Randers (b), and Åbjerg, Ringkøbing (c), in Denmark; no scale.

Abb. 7a–c *Die Hortfunde von Bondesgårde, Torsted (a), Virring, Randers (b) und Åbjerg, Ringkøbing (c), in Dänemark; o. M.*

6 Within the study by Nørgaard and colleagues in all 22 of 34 Virring-type axes have been analysed regarding their chemical and isotopic fingerprint (Nørgaard et al. 2019; Nørgaard et al. 2021).

7 The Serbian and Bulgarian copper deposits show wide ranges; for example, most of the data for the Rudna Glava mine, Bor district (Serbia), plots outside the diagrams presented in Fig. 9–10.

Museum ID	A-no.	Object	Date	Site	Context
HAM 1488	MA-170433	flanged axe, Virring-type	NBA IA	Als (Sundeved), Sønderborg	single-find
NM B15110	MA-180926	spearhead, Torsted-type		Bondesgårde, Torsted, Ringkøbing-Skjern	multi-type hoard, gravel
NM B15131	MA-180929				
NM B15117	MA-180925				
NM B15115	MA-180927				
NM B15101	MA-180928				
NM B15135	MA-180930				
NM 26072	MA-166640	flanged axe, Virring-type		Brejl, Vrads, Skanderborg	single-find, field
HOM B108	MA-170435			Ejstrup Holm, Vrads, Skanderborg	single-find, water
NM	MA-170414			unknown	unknown
NM B4489	MA-170419			unknown	unknown
NM B13535	MA-170420			unknown	unknown
HBV 2540	MA-170434			unknown	unknown
NM 10724	MA-170416			Hudevad, Åsum, Odense	single-find, meadow
NM B6821	MA-166655			Jutland	unknown
NM 21075	MA-166647			Kragebæk, Tuse, Holbæk	single-find, meadow
B10736	MA-170417			Kværkeby, Ringsted, Sorø	single-find, bog
FSM CM71	MA-170428			Nord Fünen, Odense	single-find
SØM 356	MA-170432			Saksgård, Als Sønder, Sønderborg	single-find, bog (?)
NM 26073	MA-170418			Silkeborg (near), Gjern, Skanderborg	single-find
NM B8687	MA-170422			Skannerup, Silkeborg, Gjern	single-find, under stone
NM 20948	MA-170421			Skenkelsø, Lynge, Frederiksborg	single-find, field
FSM 9708	MA-170427			Skovsbogård, Odense, Odense	single-find, meadow
NM 11820	MA-166653			Skørping, Hellum, Ålborg	single-find, gravel
NM 16783	MA-166637			Stensby, Skam, Odense	single-find, bog
NM B3963	MA-180962	flanged axe, Torsted-Tindsdahl-type		Virring, Sønderhald, Randers	multi-type hoard, field
NM B3962	MA-180963	flanged axe, Virring-type			
NM B3958	MA-180958	spearhead			
NM B3960	MA-180960	spearhead, Torsted-type			
NM B3961	MA-180961	spearhead, Torsted-type			
NM B3959	MA-180959	spearhead, Torsted-type			
AAM 1001A	MA-170440	flanged axe, Virring-type		West Himmerland, Ålborg	single-find
NM B3494	MA-170415	flanged axe, Virring-type		Øster-Mellerup, Børglum, Hjørring	single-find, field
ARV 1710A	MA-170437	flanged axe, Virring-type		Åbjerg, Hind, Ringkøbing	multi-type hoard, meadow

trates some possible scenarios in which the imported South-Eastern European axes and spearheads are one end-member of a possible mixing line, and artefacts based on fahlore (line A and B) or raw materials, respectively artefacts, from Welsh mines (line C and D) are the second end-member.

This targeted recycling would create a first generation of artefacts that imitate the style and shape of the imported pieces with a different archaeometallurgical fingerprint. Thereafter, these new items may have laid the foundation for a new mix and for the creation of a second generation of artefacts. It could be that cast residues and failed casts formed the basis for a new batch; however, depending on the time, complete artefacts might also have been remelted. Mixing line E illustrates such a scenario (Fig. 9). The axes from Als (Sundeved) near Sønderborg (HAM 1488) and

Associated artefacts	Reference	Analyical data
none	Vandkilde 1996, 432	Nørgaard et al. 2019, S2
large flanged axe, 6 flanged axes Virring-type, 40 spearheads Torsted-type	Aner/Kersten 1995, 66	
none	Vandkilde 1996, 433	
none		
unknown		
unknown	Vandkilde 1996, 432	
unknown		
unknown	Vandkilde 1996, 433	
none	Vandkilde 1996, 432	
unknown	Vandkilde 1996, 433	
none	Vandkilde 1996, 431	
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none	Vandkilde 1996, 431	
none	Vandkilde 1996, 432	
none	Vandkilde 1996, 433	
none	Vandkilde 1996, 432	
dagger blade, 3 Torsted-type spearheads, large spearhead of EBA type, 2 local-style flanged axes	Vandkilde 1996, 429	Nørgaard et al. 2021, S2 / Nørgaard et al. 2019, S2
none	Vandkilde 1996, 433	Nørgaard et al. 2019, S2
none		
local flanged axe Virring-type, 5 Torsted-type spearheads, 1 spearhead of EBA type		

Tab. 3 The axes of Virring-type and spearheads of Bagterp-type variant Torsted in Denmark for which analytical data is available. The table gives context information (including references), accompanying findings, and references to open-access analytical data.

Tab. 3 *Beile vom Typ Virring und Speerspitzen vom Typ Bagterp, Variante Torsted aus Dänemark, für welche Analysedaten vorliegen. Die Tabelle enthält Befundinformationen (einschließlich Verweise), vergesellschaftete Funde und den Verweis auf frei zugängliche Analysedaten.*

another axe from Jutland (NM B6821) could be seen as a first-generation mix, laying the foundation for another generation of axes with potentially one spearhead of the Bondesgårde hoard (B15110) as end-member. Interestingly, most of the spearheads from the Bondesgårde hoard are within the first-generation artefacts. Here a detailed techno-typological study of the 40 spearheads and additional analyses might offer further statements. The axe from Kværkeby near Ringsted on Zealand (B10736) could be one end-member of a parallel line. However, there are still several loose ends, and one of the more important ones is the possibility that the imported spearheads of European type play a distinct role. Next to the possibility that artefacts of fahlore are end-members in a potential mixing process, Switzerland's copper deposits, which have been little explored to date (see, i.e., Cattin et al. 2011; David-Elbiali 1994), may be of great importance.

Vandkilde describes the Virring-type axes as a local Scandinavian style with no convincing parallels in Central and Eastern Europe (Vandkilde 1996, 101). However, some parallels can be detected, all dating to 1700–1600 BC. W. David (2015) names three hoard finds in Southern Central Europe that contain, besides a possible Virring-type axe, also simple socketed spearheads similar to the Bagterp-type: the Lanquaid hoard with seven axes (one has the characteristic distinctly protruding cutting edge of the Virring axes), a small spearhead, and pins and rings; the Schillwitzhausen depot, Pfaffenhofen district (Germany) with three axes and a spearhead; and the Neumětely depot in central Bohemia with five axes, a simple spearhead, and pins and rings (David 2015, 102–104.). Further south-east, David postulates that the first appearance of spearheads is connected to the Hajdúsámson-Apa Horizon, which would make the socketed spearheads contemporaneous with the (in the north, well-known) Hajdúsámson-Apa swords (David 2006, 222.).

It is thus challenging, based on the current state of research, to trace a South-Eastern European predecessor of the Virring axes to a location near the Serbian/Bulgarian mining region and, in consequence, to explain the evidence that the earliest socketed spearheads in Southern Scandinavia are of South-Eastern European metal. In order to test the assumption made in this text that Virring-type axes and spearheads came to Denmark when metal supply networks were rearranged and the borders of the Únětician Culture became permeable, some tasks must still be fulfilled. A closer look at the Virring-type axes inside and outside Scandinavia is needed, from a techno-typological angle, to distinguish potential minor technological differences that might indicate the »first« axe with the characteristic distinctly protruding cutting edge. Additionally, we need to have profound and precise chronological knowledge regarding the appearance of the simple Bagterp-like socketed spearheads to reconstruct the possible exchange networks between 1700–1600 BC along the borders of the changing Únětice Culture.

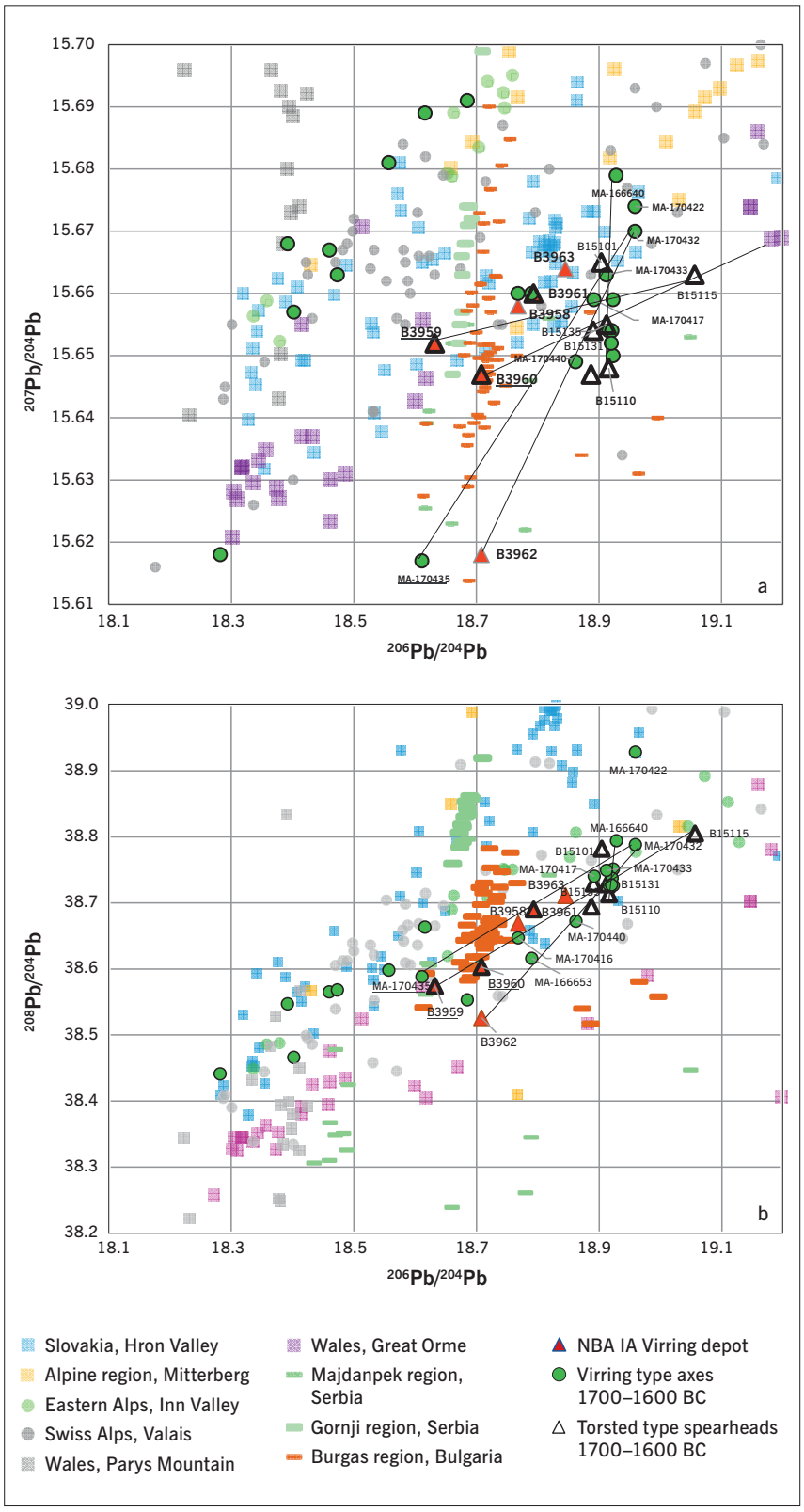

Fig. 8a–b Lead isotope ratios of the analysed Virring-type axes and socketed spearheads (a) compared to the known metal deposits in Early Bronze Age Europe (b). The black lines indicate possible mixing scenarios; for a detailed picture, see Fig. 9. Artefact data from Nørgaard et al. 2019; 2021; 2022. The ore-related data are from: Great Orme mining region and Central Wales (Fletcher et al. 1993; Joel et al. 1997; Rohl 1996; Rohl/Needham 1998; Williams 2014; Williams 2018); Alderley Edge mining region (Rohl 1996; Rohl/Needham 1998); Alpine ores (Cattin et al. 2011; Höppner et al. 2005; Pernicka et al. 2016; Schubert/Pernicka 2013); Hron Valley, Slovakian Ore Mountains (Modarressi-Teherani et al. 2016; Schreiner 2007); Serbian mining region, selection (Pernicka et al. 1993; Radivojević et al. 2010); Burgas region, Bulgaria (Kunze/Pernicka 2020; Stos-Gale et al. 1998).

Abb. 8a–b *Bleiisotopenverhältnisse der analysierten Beile vom Virring-Typ und Speerspitzen mit Tülle (a) im Vergleich zu den bekannten Metallvorkommen im frühbronzezeitlichen Europa (b). Die schwarzen Linien markieren mögliche Vermischungsszenarien; siehe Abb. 9 für eine detailliertere Darstellung. Artefaktdaten aus Nørgaard u. a. 2019; 2021; 2022; Herkunft der Daten zum Erz: Bergbauregion am Great Orme und in Zentralwales (Fletcher u. a. 1993; Joel u. a. 1997; Rohl 1996; Rohl/Needham 1998; Williams 2014; Williams 2018); Bergbauregion von Alderley Edge (Rohl 1996; Rohl/Needham 1998); Erze aus den Alpen (Cattin u. a. 2011; Höppner u. a. 2005; Pernicka u. a. 2016; Schubert/Pernicka 2013); Hrontal, Slowakisches Erzgebirge (Modarressi-Teherani u. a. 2016; Schreiner 2007); serbische Bergbauregion, Auswahl (Pernicka u. a. 1993; Radivojević u. a. 2010); Region um Burgas, Bulgarien (Kunze/Pernicka 2020; Stos-Gale u. a. 1998).*

Conclusion

Previous studies of the metal supply networks to Southern Scandinavia in the Early and Middle Bronze Age (i.e. Nørgaard et al. 2019; Nørgaard et al. 2021; Ling et al. 2014) have indicated that metallurgy in Southern Scandinavia was advanced not by the import of raw materials, but by the import of metal objects and their reuse. This article aimed to identify the parameters of this artefact-driven metal trade. It could be shown that the early adoption of tin bronze in Scandinavia's Late Neolithic was a result of the active reuse of high-tin bronzes imported from the British Isles. The high-tin concentrations in a few particularly elaborately designed local axe types demonstrate the reuse of English and Welsh

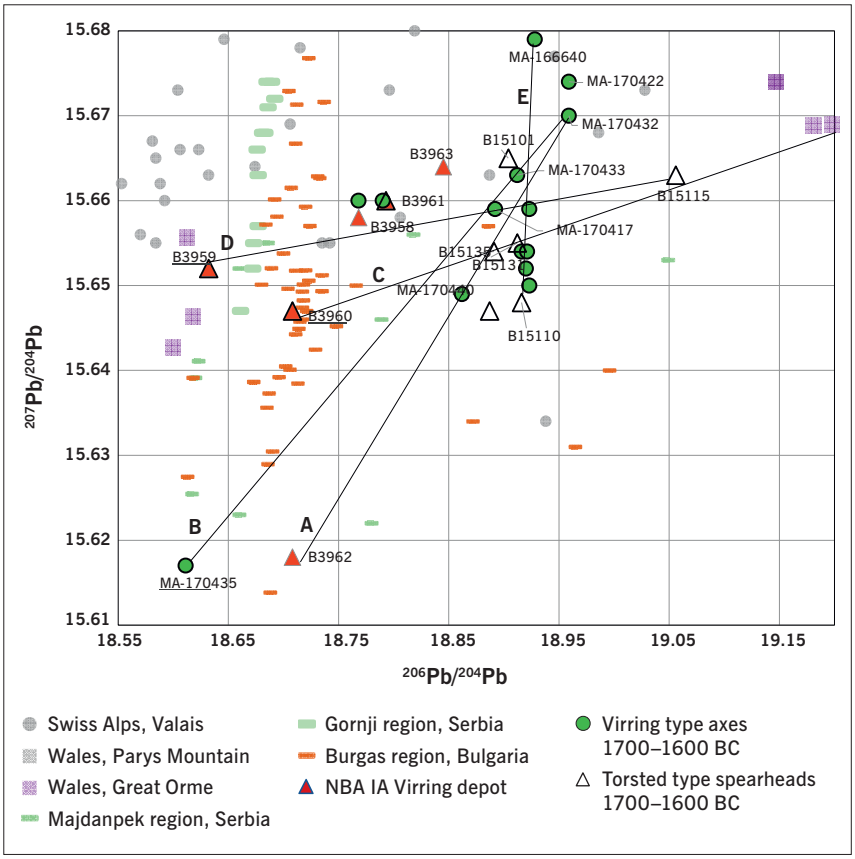

Fig. 9 Possible mixing scenarios within the group of Virring-type axes and Torsted variant spearheads based on Fig. 8. Scenario A/B and C/D shall be considered as the initial mixing of imported artefacts and existing materials. The resulting first-generation artefacts are lined up on the assumed black lines. These artefacts can be regarded as the end-members of a new mix in a second scenario. Background data and key as in Fig. 8.

Abb. 9 *Mögliche Vermischungsszenarien innerhalb der Beile vom Virring-Typ und der Speerspitzen der Torsted-Variante auf Grundlage von Abb. 8. Die Szenarien A/B und C/D sollten als erste Vermischung importierter Artefakte mit existierendem Material betrachtet werden. Die daraus entstandenen Artefakte der erster Generation liegen auf den angenommenen schwarzen Linien. Diese Artefakte können als Endglieder einer neuen Vermischung in einem zweiten Szenario betrachtet werden. Hintergrunddaten und Legende wie in Abb. 8.*

metal for local production. In addition, the reuse of the Ni-free *Ösenring* metal in local axe production could be identified. It is highly likely that Únětician axes, as well as loop neck-rings, were the main suppliers for the local production in the LN II period in Denmark. But there is also evidence of a continued supply of artefact-metal used as raw material in the following period. In NBA IA, the material culture of Southern Scandinavia was enriched by a new artefact type, the spearhead, which is visible in hoard finds from around 1700 BC. Until now, it was assumed that the Únětician Culture influenced the trade connection from the south-east to the north and that the sword, which appears around 1600 BC in Denmark, was the first artefact that testified to the active exchange networks with the South-Eastern European Bronze Age cultures. Archaeometallurgical data of Virring-type axes suggests now that some axes and metal of South-Eastern European origin came to Denmark as a result of an expanding metal trade already around 1700 BC. Whether the idea for the spearheads or the actual artefact was part of this exchange is unclear. It is, however, evident that Virring-type axes and the first spearheads of Torsted-type were made in local Scandinavian workshops, and it is highly possible that axes of South-Eastern European metal were reused to produce both the axes and spearheads.

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Source of figures

1 author
2 author; using QGIS.org (2024), QGIS Geographic Information System, https://qgis.org on Natural Earth maps; the artefact data is from the catalogues from Harbison 1968; Harbison 1969; Megaw/Hardy 1938; Needham 1983; Vandkilde 1996; Burgess/Schmidt 1981; Vandkilde 2017; and for the Ösenhalsringe the catalogues from Junghans et al. 1960; Junghans et al. 1968; Junghans et al. 1974; Krause 2003.
3 grafic author; drawings E. Koch, L. Hilmar
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Massive shaft-hole axes were axe currencies: The social life of the Fårdrup axes

Anne Lene Melheim

Were the Fårdrup axes also ingots?
Were they a convenient way of locking up wealth
in measurable form – the wealth in this case
being a metal that could be put to practical use
by remelting or could be used in exchange?
(Liversage 1989, 54)

Zusammenfassung

Massive Schaftlochäxte als Währung: das Sozialleben der Fårdrup-Äxte

Als Beitrag zur gesellschaftlichen Bedeutung von Äxten widmet sich dieser Aufsatz einer Gruppe von Bronzeäxten aus der Nordischen Bronzezeit, nämlich den massiven und schweren Schaftlochäxten vom Fårdrup-Typ (ca. 1600–1500 v. Chr.). Ich stimme mit der vorangehenden Forschung darin überein, dass die Fårdrup-Äxte mindestens drei Funktionen erfüllten: Sie waren hochentwickelte symbolische Waffen, metallene Vorformlinge (Bronzebarren) und eine Währungseinheit. Obwohl der Fårdrup-Stil eindeutig von Metallarbeiten aus den Karpaten inspiriert ist, stellt er selbst eine Schöpfung der nordischen Welt dar. Die altmodische Form der Axtköpfe geht auf frühere, einfache Schaftlochäxte aus Stein zurück. Importiertes Metall wurde durch das Gießen in diese Form und diesen Stil in ein nordisches Wertesystem übertragen. Ich stelle die Hypothese auf, dass die Fårdrup-Äxte sowohl als Vorform einer Währung oder »Axtwährung« dienten, die auf einer oder mehreren regionalen Gewichtseinheiten beruhte, als auch als Garanten für die hohe Qualität des Metalls fungierten. Der Bedarf nach einer solchen Markenbildung entstand wohl mit der Ankunft einer Neuheit – dem Schwert –, die eine stärkere Kontrolle des Zinngehalts nötig machte, um Metall zu erhalten, das Klingenqualität besaß.

Schlagwörter Bronzezeit, Schaftlochäxte, Metallumlauf, Provenienz, Gewichtsregulierung, Markenzeichen

Summary

As a contribution to the topic of the social life of axes, this article addresses a group of bronze axes from the Nordic Bronze Age: the massive and heavy shaft-hole axes of the Fårdrup type (c. 1600–1500 BC). I argue, in line with previous research, that the Fårdrup axes served at least three functions: They were high-end symbolic weapons, metal preforms (bronze ingots), and value denominators. Although clearly inspired by Carpathian metalwork, the Fårdrup style itself was a creation of the Nordic world, and the old-fashioned axe shape drew its authority from earlier simple shaft-hole axes of stone. When being cast into this particular axe shape and style, incoming metal was being transformed into a Nordic value system. I hypothesise that the Fårdrup axes functioned both as a form of proto-currency or »axe currency« based on one or several regional weight units and as a guarantee for high quality metal, a brand. Arguably, the need for such branding arose with an important newcomer – the sword – which demanded stronger control of tin contents in order to obtain blade-quality metal.

Keywords Bronze Age, shaft-hole axe, metal circulation, provenance, weight-regulation, branding

Introduction

Metal circulated in various shapes during the Bronze Age. Whereas transportation of ore in large quantities over longer distances seems unlikely, we positively know that ingots of copper and tin were traded interregionally, as were already alloyed objects and various preforms, often taking the shape of rings, rods, and axes. Yet, a number of questions regarding metal circulation remain open. For example, whether and how distribution chains for copper and tin were interlinked, and how transactions were managed between parties belonging to different cultural spheres. It is a fact that crafted objects often circulated outside their area of production; however, provenance analysis of the metal has demonstrated that there is no simple equation between craft traditions and metal supplies.

A fresh look at the Fårdrup axes can shed new light on these issues. The Fårdrup axes date to c. 1600–1500 BC and thus to the second half of the earliest phase of the Nordic Bronze Age, period NBA Ib, which runs parallel to the beginning of the Middle Bronze Age and Reinecke's Bz B1 in Central European chronology (Vandkilde 1996, 226–227). The Fårdrup style, although inspired by metalworking styles in the Carpathian Basin, was developed in the Nordic region. M. Malmer famously interpreted the Fårdrup axe as a bronze ingot and as a denominator of value

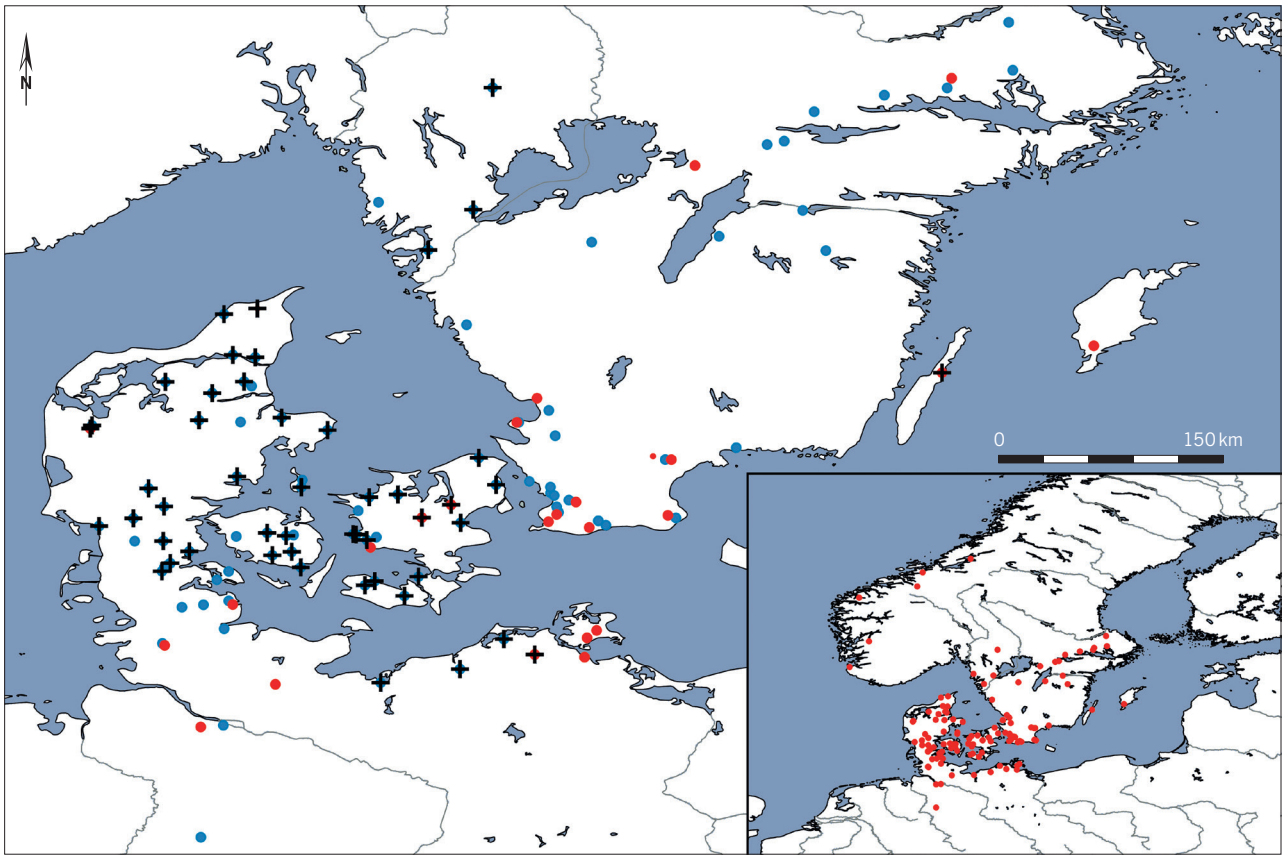


Fig. 1 Distribution of Fårdrup and Valsømagle axes (c. 1600–1500 BC) in South Scandinavia. Notice the north-westerly distribution of axes of the Fårdrup type on the smaller map. Signatures on the main map indicate: Fårdrup axes (blue dots), Valsømagle axes (red dots), analysed axes (crosses).

Abb. 1 *Verbreitungskarte der Fårdrup- und Valsømagle-Äxte (ca. 1600–1500 v. Chr.) in Südskandinavien. Man beachte die nordwestliche Verbreitung der Äxte vom Typ Fårdrup auf der kleineren Karte. Legende der großen Karte: Fårdrup-Äxte (blaue Punkte), Valsømagle-Äxte (rote Punkte), analysierte Äxte (Kreuze).*

(Malmer 1989; Malmer 1992; cf. Liversage 1989, 54). I will pursue Malmer's ideas further and maintain that these axes were preforms that both embodied and represented metal values. They were a form of proto-currency or axe currency, but also a brand.

The simple shape anchored the Fårdrup axes in an already established political economy system based on, among other things, axe values, yet they were themselves useless as axes. I will argue in this article that, by being cast into this particular shape and style, imported metal was enculturated and transformed into a Nordic system of value. Despite the standardised shape of the axes, regional variations can be observed. This allows me to hypothesise that there was a connection between the Fårdrup axes, in their capacity as preforms, and local metalworking traditions in the regions where they circulated. Crucial for my analysis are the patterned variations in ornamental schemes and weights, already observed by Malmer, and the new insights emerging from provenance studies of the axes' metal. On the basis of element analysis, D. Liversage (1989, 56) argued for a single source. However, 72 of the 120 known Fårdrup axes have recently been subjected to lead isotopy, which revealed considerable variation and, possibly, different origins of the copper (Ling et al. 2023; Nørgaard et al. 2023). This invites a new discussion about these axes and their role in the circulation of metals.

Axe and ring currencies

Throughout history, various axe shapes have embodied culturally established symbolic and economic values. Prior to the Bronze Age, stone axes had circulated as valuables across Eurasia for millennia (e.g., Bradley/Edmonds 1993). The fact that metal axe blades evolved into a proto-currency during the Early Bronze Age can thus be understood as a development from prior practices (Kuijpers/Popa 2021). However, the use of axes as a currency is a global phenomenon that extends far beyond the European Bronze Age. For instance, in pre-Columbian Mesoamerica, non-functional axes of copper – often nicknamed ›axe money‹ – could be used for a range of purposes: as burial goods, as a medium of exchange, and as wealth to be stored in caches (Cobb et al. 2022). Another example of how valuables can be converted and adjusted to a range of circumstances and purposes is the highly dynamic value system centring around ingots of copper in precolonial Africa (Herbert 1984). Some were shaped as crosses, others as rods that could be made into bracelets and necklaces which, when cut up, served as currency for smaller purchases. Ingots of copper were thus a form of proto-currency used in economic transactions, but they also entered other social and ritual spheres. For instance, in south-eastern Nigeria, certain ring-shaped copper ingots called manillas were used to buy foodstuffs, to compensate

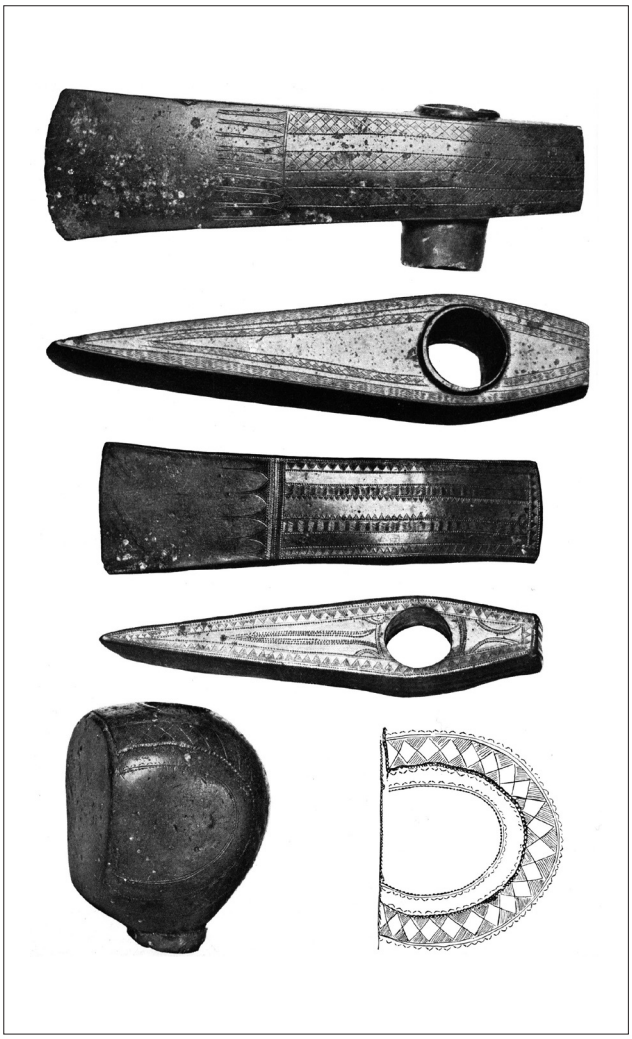


Fig. 2 The eponymous Fårdrup hoard from Tranderupgård, Fårdrup, Zealand (Denmark), with two axe heads and a mace head. Notice the fish-blade emblem on the smaller axe; no scale.

Abb. 2 *Der eponyme Fårdrup-Hort aus Tranderupgård, Fårdrup, Seeland (Dänemark), mit zwei Axt- und einem Keulenkopf. Man beachte das Fisch-Klingen-Motiv auf der kleineren Axt: o. M.*

diviners, to satisfy court claims, to contract for a spouse, and as gifts to the dead (Herbert 1984, 185–207). These examples are valid analogies for the European Bronze Age because they showcase the many and varied practices that contribute to the curation of metal valuables and value systems.

Likewise, we see that copper and bronze were circulated and exchanged in various forms in Bronze Age Europe – as rings, rods, and axes – and the use of cut-up metal as ›small change‹ has been demonstrated (Ialongo/Lago 2019). Based on weight accordances, the Early Bronze Age Central European *Ösenringe* have been identified as a proto-currency. Arguably, a process of commodification took place with the evolution from ornament via ring money to currency (Lenerz de-Wilde 1995; Lenerz de-Wilde 2002). R. Krause and E. Pernicka (1998) introduced the concept of *Barrengeld* (ingot money) to characterise the *Ösenringe*. The fact that two-thirds of the known copper of this type is represented by the rings themselves seems to indicate that they functioned as a means of exchange in a value system where metal type, shape, and value corresponded (Krause/Pernicka 1998). A concentration of hoards occurs in the Alpine foothills and river valleys at equal distance from several significant copper mines. However, the *Ösenringe* were subject to different forms of ritual deposition, varying, as was pointed out by H. Vandkilde (2005), with distance from the source. She argued that a transformation of value occurred when rings entered more far-away places, like Scandinavia.

More knowledge is needed about how already alloyed bronze circulated in Bronze Age Europe, as was pointed out in a recent article highlighting semi-finished products such as bronze axes as potential candidates (Berger et al. 2022). Palstaves are examples of bronze axes circulating widely in Northern Europe in the Middle Bronze Age which are perhaps best understood as just ingot money (Fontijn/Roymans 2019). Interestingly, the Acton Park shield-patterned palstaves all seem to have been made of copper from one supplier: the Great Orme mine in Wales (Williams/Le Carlier de Veslud 2019). This article once more puts the Fårdrup axes on the agenda as bronze ingots or preforms. Considering their distribution pattern, it does not seem likely, however, that they were primary ingots from the copper producing communities. Primary ingots aimed at interregional consumption and exportation are more likely found among the bun (plano-convex) ingots occurring in hoards, settlements, and ship-wreck sites in Europe and, occasionally, in Scandinavia (Berger et al. 2022a; Ling et al. 2023 with references). Interestingly, in a contemporary source from Egypt, bronze axes are explicitly listed among luxury commodities aimed at trade (Walburton 2023, 7)[1].

The origin of the Fårdrup axe

Judging from find contexts and material properties, like many of their stone predecessors, the Fårdrup axes were status objects as well as ritual objects. Malmer (1989) counted 118 Fårdrup axes in present-day Scandinavia and Germany, with stray finds as far north as Trøndelag in Central Norway. H. W. Nørgaard et al. (2023) adjusted the number of axes to 120 (Fig. 1). The overwhelming majority have been found within the borders of present-day Denmark, where they cluster in Zealand and on Funen. Most are stray finds or single depositions; only six hoard finds are known, some of which are single type hoards with two or more axes. From Zealand comes the eponymous find with two axes and a Fårdrup style mace head (Fig. 2) and the larger Bregninge hoard with nine axes. Twice, Fårdrup axes occur in association with flanged axes of the Underåre type.

1 A report from the trade hub Avaris during the Hyksos period mentions »[...] hundreds of ships of fresh cedar which were filled with gold, lapis, silver, turquoise, bronze axes without number [...], moringa-oil, incense, fat, honey, willow, box-wood [...]« (Redford 1997, 14).

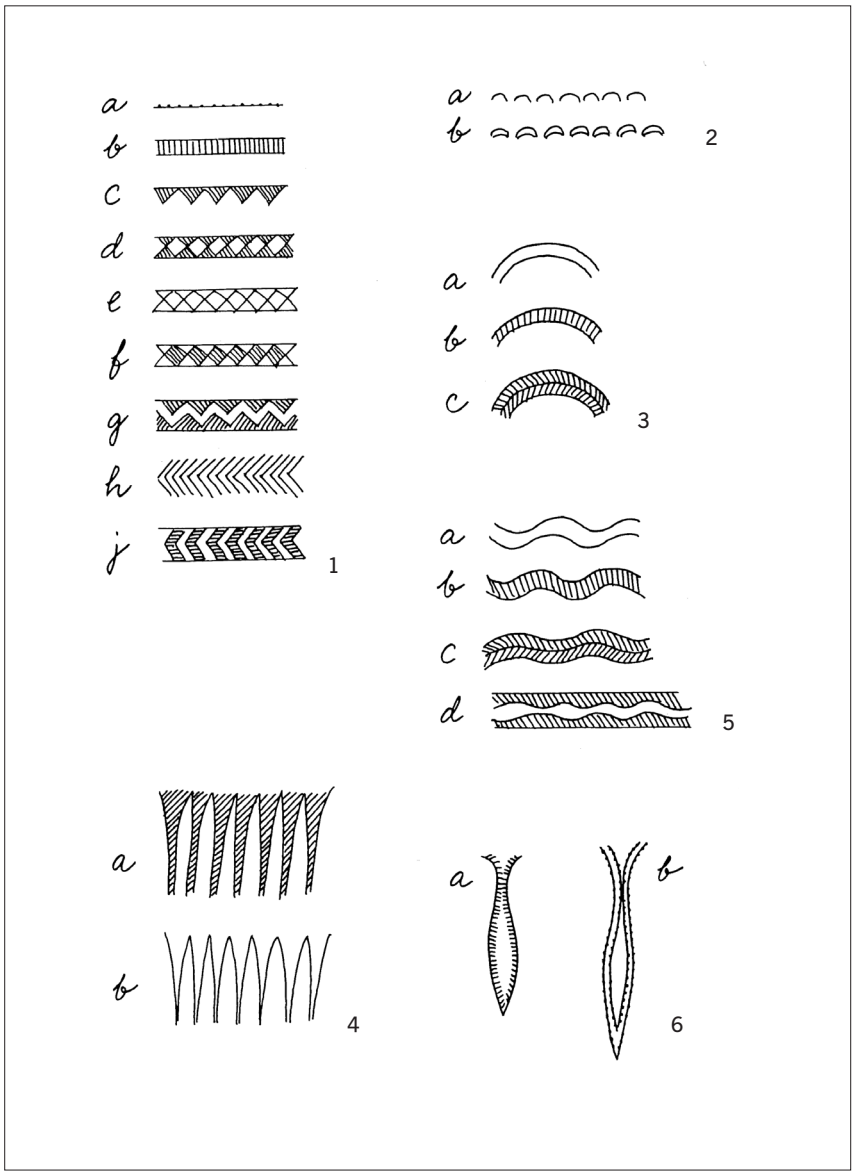


Fig. 3 Ornaments on Fårdrup axes. 1 Linear designs; 2 Small arcs; 3 Big arcs; 4 Arcades; 5 S-curved lines; 6 The fish motif.

Abb. 3 *Ornamente der Fårdrup-Äxte. 1 geradlinige Muster; 2 kleine Bögen; 3 große Bögen; 4 Arkaden; 5 Schlangenlinien; 6 Das Fisch-Motiv.*

Malmer (1989) argued that the majority of Fårdrup axes are much too heavy to be functional axes, hence he concluded that their main purpose was to materialise, display, and exchange metal values. Among other things, he based this on the metal's porous structure and the often uneven underside, indicating that the axes had been cast in open moulds. Besides, the edges do not seem to have been hardened (Liversage 1989, with references). Almost half (44 %) of the known Fårdrup axes had been decorated. With some exceptions, the ornaments are shallow and seem as a rule to have been applied post-casting (Vandkilde 1996, 227; Nørgaard et al. 2023). Few axes show identical designs; variation was created through a recombination of a restricted number of geometrical features (Fig. 3).

Fårdrup axes are otherwise characterised by their unassuming shape, similar to the simple shaft-hole axes of stone emerging in the Nordic Late Neolithic (c. 2350–1700 BC) and with temporal overlap during the Early Bronze Age (c. 1700–1500/1300 BC; Østmo 1978; Lekberg 2002, 75–86, with references). The similarities have been explained as a form of material referencing or skeuomorphism from stone axe to bronze axe and vice versa (Brøndsted 1958, 259; Stensköld 2004, 71; Frieman 2010). Although imitation from the older stone axes to bronze axes may seem the more likely hypothesis, it is striking that some – presumably late – stone axes show ornaments and sharp angles, arguably copycatting metal shapes. Quite possibly, inspiration has gone both ways. However, the different spatial distribution of stone axes versus bronze axes must also be taken into account. While Fårdrup axes are concentrated in Denmark and Scania, simple shaft-hole axes are more numerous on the Scandinavian Peninsula, where they occur in the tens of thousands (Lekberg 2002, 108–109). According to P. Lekberg, the circulation of simple shaft-hole axes was initially controlled by an elite; they thus retained their value for centuries, fuelling the political economy, until they were devalued and replaced by bronze axes during the Bronze Age (Lekberg 2002, 298).

The shift from stone to bronze, from functional axe to symbolic axe, provides insights into how values were being

Fig. 4 Two of the three Fårdrup axes from Bækbølling, Føvling, Jutland (Denmark); no scale.

Abb. 4 *Zwei der drei Fårdrup-Äxte aus Bækbølling, Føvling, Jütland (Dänemark); o. M.*

established, negotiated, and authorised. In a seminal article, Vandkilde (2014) argued that the Carpathian region and the Hajdúsámson-Apa metalworking horizon was crucial for the breakthrough of the Nordic Bronze Age c. 1600 BC. At the crossroads between the Eurasian steppes, the Aegean world, and temperate Europe, a transitionary culture emerged which took up elements from different places. Foreign styles and emblematic symbols were incorporated into local craft traditions, from which a number of distinguished local styles – among them the Fårdrup style – were born. Z. Kölcze argued that Fårdrup axes were used actively to create cross-cultural bonds and to negotiate social and political power and identity. She also pointed out that such transformations are »largely dictated by the demands of the receiving community« (Kölcze 2014, 86).

The value system created around the simple shaft-hole axes is relevant for our understanding of the Fårdrup axes, since it was a part of the political economy context within which these bronze axes were created and circulated. However, despite the noted continuity of practice in the Nordic region, the two axe categories seem to have led quite different social lives. Contrary to Fårdrup axes, simple shaft-hole axes were frequently buried with the dead; moreover, and importantly, these axes tend to be worn and often reworked (Lekberg 2002, 214). On the basis of the differences in length between axes from hoards, burials, and settlement sites, in decreasing order of magnitude, Lekberg argued that: »In a perspective of potential, practical use-value, hoard-axes may be viewed as more valuable objects than grave-axes« (Lekberg 2002, 305). With one exception, Fårdrup axes do not occur in burials (Vandkilde 1996, 227). They were, as already pointed out, mostly sacrificed singly, or in single-type hoards.

A case study from Bækbølling in Føvling, Jutland (Denmark), shows how the wider landscape setting can further inform our understanding of the Fårdrup axes (Fig. 4). Here, three large axes were found on two different occasions in the same field, a former wetland area (Broholm 1938). The three axes are very similar in shape, decoration, and metrology, a factor used to argue in favour of a single deposition event (Poulsen/Grundvad 2019). The site is surrounded by other contemporary evidence of an affluent community with, among other things, monumental longhouses and high-status burials. This indicates that axe depositions were not isolated events; rather, they were integrated into an already inhabited cultural landscape. Flint skeuomorphs such as the Åtte sword, deposited with a simple shaft-hole axe of stone in a burial c. 3 km from Bækbølling, provide insight into how new innovations were adapted to existing local craft traditions. The hybridisation process that led to the reinvention of an established axe shape in the Nordic world was a ›cross-craft‹ in the sense that it involved flint knappers, as is indicated also by the unique scimitars of flint and bronze belonging to the same horizon. The first generation of metal swords in the Nordic world reveals a similar pattern of adaptation and recreation. While some swords were imported from Central Europe, other swords can be categorised as local copies or derivates (Vandkilde 1996, 224–225; Bunnefeld 2016).

Fish, dagger, or sword?

A hoard of eight short-swords from Dystrup in Jutland (Denmark), dated to c. 1600–1500 BC (Fig. 5), allows me to hypothesise that there was a close connection between Får-

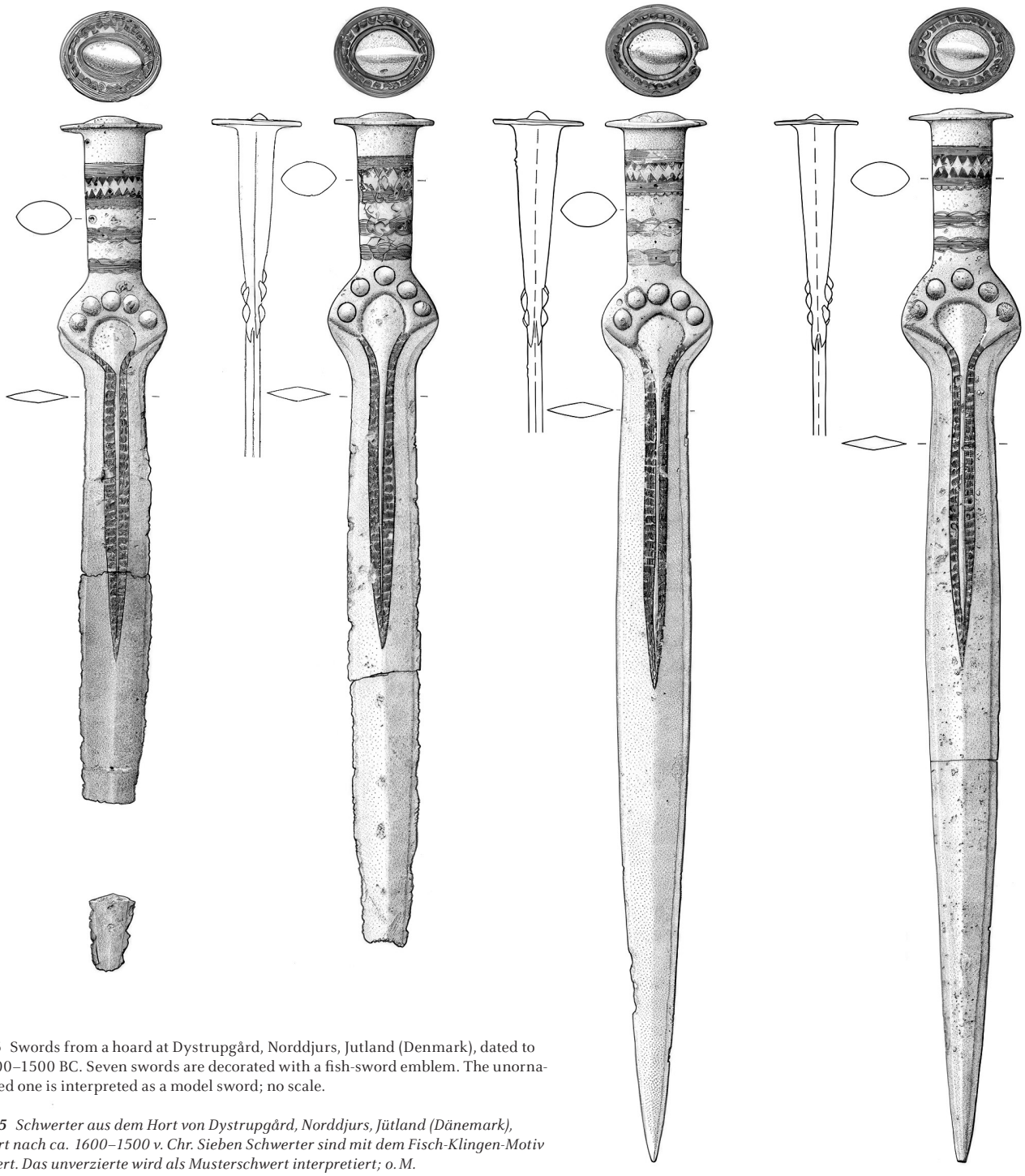
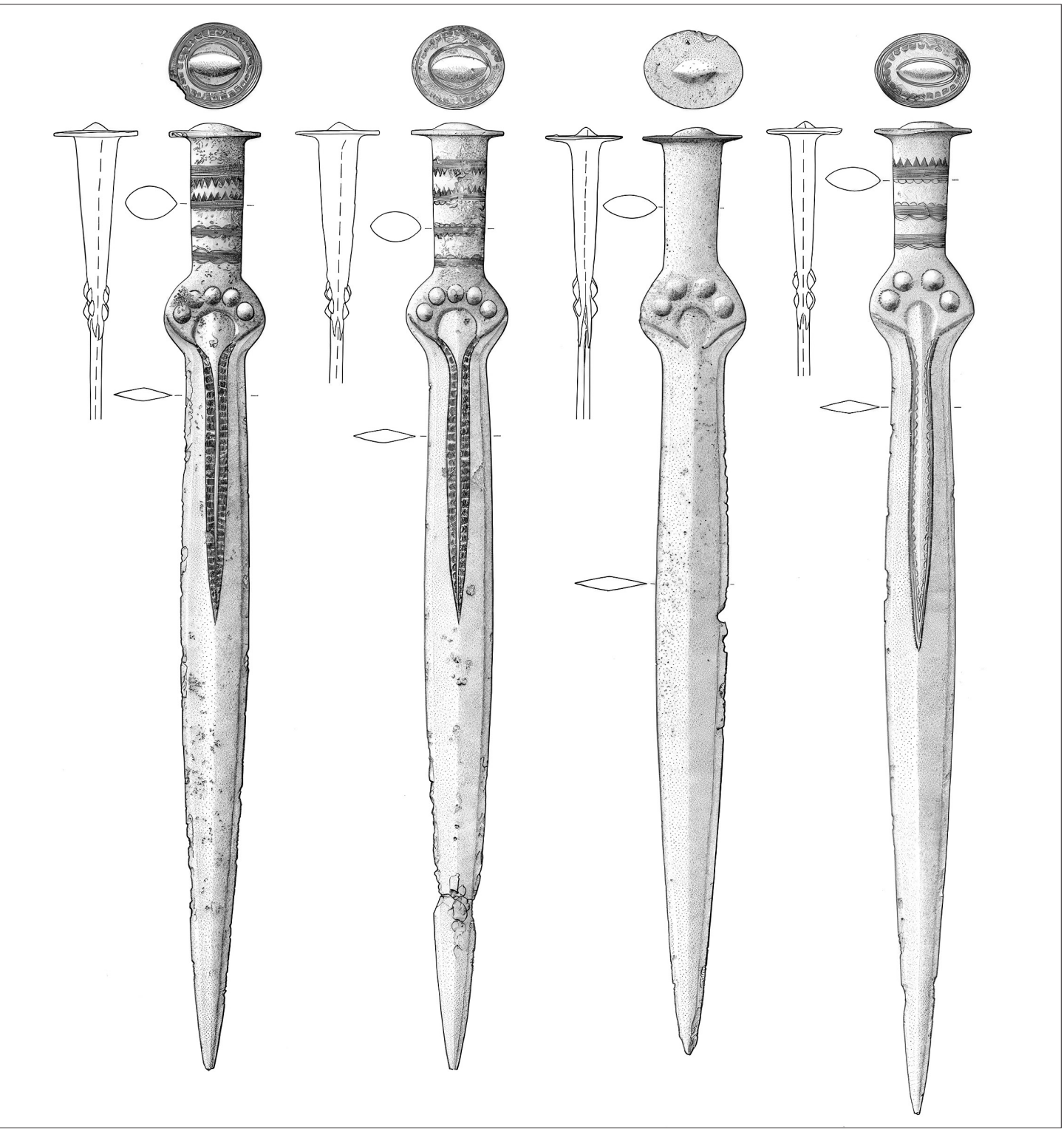


Fig. 5 Swords from a hoard at Dystrupgård, Norddjurs, Jutland (Denmark), dated to c. 1600–1500 BC. Seven swords are decorated with a fish-sword emblem. The unornamented one is interpreted as a model sword; no scale.

Abb. 5 *Schwerter aus dem Hort von Dystrupgård, Norddjurs, Jütland (Dänemark), datiert nach ca. 1600–1500 v. Chr. Sieben Schwerter sind mit dem Fisch-Klingen-Motiv verziert. Das unverzierte wird als Musterschwert interpretiert; o. M.*

drup axes, in their capacity as preforms, and other metalwork produced locally within the Nordic realm. The ornamentation on these swords is considered to be a mix of several styles: Hajdúsámson-Apa, Zajta, and Fårdrup. When publishing the find, L. W. Rasmussen and N. A. Boas pointed to a striking correspondence: »By weight, the eight swords represent approximately the same amount of metal as the great axe in the Fårdrup hoard« (Rasmussen/Boas 2006, 104). The weight of the great axe is 3170 g, compared to the eight swords which, in their current state, weigh 3110 g in total. Intriguingly, this indicates that the eight short-swords could have been produced from one Fårdrup axe of a size similar to the largest axe in the eponymous hoard. The smaller axe of this hoard is about half the size, and, with a weight of 1547 g, it would have yielded four swords of the Dystrup type.

In light of this, it is remarkable that the smaller Fårdrup axe has a centrally placed emblem on the front, shaped like a dagger or sword blade. It seems clear that this so-called fish motif, or curved ogival V-shape, had been borrowed



from contemporary or slightly older Hungarian bronze axes. It can be read as both a representation of a fish – a symbol of cosmological importance (Vandkilde 2014) – and a blade (dagger or sword; Malmer 1989), or a combination of the two, henceforth the fish-blade emblem. Such material transformations were commonplace in later Nordic Bronze Age iconography (e.g., Ahlqvist 2024), where recurring images (e.g., ships and horses) can be seen as belonging to a system of signs based on pictorial metonyms or kennings (Melheim 2022). Moreover, the selective deposition of swords in rivers and lakes may indicate that there was an affinity between weapons and running water bodies during the early part of the Nordic Bronze Age (Melheim/Horn 2014). The fact that swords at some rock-art panels in Scandinavia can be seen floating or swimming in a waterway along with ships, for instance at Ekenberg in Östergötland (Sweden; Fig. 6) is another indication that the fish and the sword could refer to each other. Strikingly, the fish-blade emblem is present on the Dystrup swords themselves.

Fig. 6 Sword motives on rock art panel at Ekenberg, Östra Eneby, Östergötland (Sweden).

Abb. 6 *Abrieb der Schwertmotive der Felsritzungen von Ekenberg, Östra Eneby, Östergötland (Schweden).*

The eight swords show limited signs of usage, and the one undecorated sword has been interpreted as a model sword because it lacks surface finish and the cutting edge is not hardened (Melheim/Horn 2014). In light of these observations and the fact that it is a dryland hoard, an interpretation of Dystrup as a metalworker's hoard or cache is a concrete possibility. While two of the analysed swords have almost identical trace element compositions and tin contents of c. 7.3 and 7.7 %, the third sword has a somewhat different composition with, among other things, a tin content of only 3.2 % and a very low or absent arsenic and nickel content. Interestingly, the composition of the two finished swords are consistent with metal types and tin values considered typical for Fårdrup axes found in Denmark (Liversage 2000, 74–75).

Isotopically, the three swords match best with copper from the oxidised malachite-goethite and chalcopyrite lodes at Great Orme in Wales (Melheim et al. 2018; Williams 2023). D. Berger et al. (2022) discussed whether the Dystrup metal could instead have come from Slovak copper ores, in analogy with other Nordic swords of the Hajdúsámson-Apa type and derivates thereof. This argument seems to be governed by the traditional idea of a link between metal supplier and metalworking styles. However, on the contrary, recent research has indicated that the crafting of metals was only loosely connected or even unrelated to the supplier (Ling et al. 2014; Ling et al. 2019). Moreover, to produce one-piece blades like the Dystrup swords, Nordic metalworkers used casting techniques uncommon in the Carpathian Basin (Bunnefeld 2016). The suggestion that bronze and copper ingots provided by different metallurgical centres ended up at local workshops in the Nordic realm, where they were mixed and further processed to make artefacts (Berger et al. 2022), is indeed intriguing. This implies that incoming metal was transformed at local hubs before it was distributed further: a topic we shall now turn to in light of the hypothesis that the Fårdrup axes were preforms.

Considering the noted correlations between axe preforms and finished blades, one may ask whether the signs or emblems on the Fårdrup axes can be read as references to the artefacts ›hidden within‹ or the capacity of the preform. Other and more frequent symbols are arcades, occurring in various numbers, which may reflect a counting system of some sort, possibly correlating with axe weights. For instance, the large axe from the Fårdrup hoard has nine arcades, the small has five, and an axe from Fellingsbro in Västmanland (Sweden), weighing one third of the large Fårdrup axe and arguably based on the same weight unit, has four (Fig. 7). If this is the case, the overlapping metal qualities between axes and blades as showcased by the Dystrup swords may suggest that the alloy was a crucial factor. While axes were old news, the sword was the real innovation of the Bronze Age – a weapon that created a demand for high quality metal, especially in regard to the management of tin/lead contents (Molloy 2011; Bruyère et al. 2024). I therefore posit that symbols such as the fish-blade emblem, arcades, etc., were a means to express the inherent value of the preforms in terms of the amount of metal but also, potentially, the quality of the alloy, e.g., the ›blade quality bronze‹. Metal analyses may help confirm or disprove this hypothesis.

Fårdrup quality metal

The fact that Fårdrup axes are not present in the areas the raw materials came from must indicate either that alloying and casting occurred at workshop sites in the Nordic region

on the basis of imported copper and tin or that the axes were re-cast here from already alloyed metal. An intra-period division around 1600 BC with a shift from fahlores to a new metal produced from chalcopyrite (referred to as AsNi by Liversage 2000) coincided with the rise of the Nordic Bronze Age and the collapse of the Únětice Culture. It has been a topic of much discussion whether this new type of metal represented a unitary source or several producers following the same recipe and using broadly similar ore sources. While Liversage (2000) and Pernicka et al. (2016) opted for Mitterberg, L. Melheim et al. (2018) argued for a range of different suppliers. Nørgaard et al. (2021) also pointed out that several copper sources could have contributed to the AsNi copper, alternatively that there could be one single supplier utilizing a deposit with large internal variation in lead isotope ratios, or that this increasingly standardised type of metal resulted from mixing. Which is the most feasible, if we look at the Fårdrup axes in isolation?

Within the ranges of the AsNi metal, which covers the vast majority of Danish analyses from 1600 to 1500 BC, the Fårdrup axes form a tight grouping, previously referred to as FAARDMET (Liversage 1989). On the basis of the homogenous chemistry and narrow tin ranges indicated in the SAM[2] dataset, Liversage (1989; 2000, 74–75) argued that the then >60 analysed Danish axes had been produced from one lot of metal. Tin ranges appeared to be very narrow, with tin at 7.01 ± 1.20 %. Contrary to Liversage's idea of one common origin, interpretations based on new elemental analyses and lead isotopy of 72 axes (74 analyses) from Denmark, Sweden, Norway, and Mecklenburg-Vorpommern point to three or four different ore regions (Ling et al. 2023; Nørgaard et al. 2021; Nørgaard et al. 2023). This is interesting in light of the observation made by C. Cullberg (1968, 286; 290–291), based on metal compositions, that there were in fact regional groupings within Scandinavia[3].

Nørgaard et al. (2023) published new data on 70 NBA 1b axes from Denmark (on the basis of samples from the SAM project) belonging to two different metalworking styles of the Nordic Bronze Age: Fårdrup (63) and Valsømagle (7). Noted inconsistencies between the two axe types in regard to their raw materials were argued to be related to regional differences between workshops and of chorological rather than chronological relevance. Of the analysed Fårdrup axes from Denmark/Germany, a majority plot in isotope group 3 (Nørgaard et al. 2021). This grouping was interpreted as originating from Britain (Great Orme in Wales and Alderley Edge in England) and the Eastern Alps (Mitterberg in Austria). While some of the axes in this cluster were pinpointed to a particular supplier, the majority were interpreted as being a mix of the two. This was justified by the cloud-like accumulation of data in the isotope as well as the elemental plots, and it was argued that mixing is likely to have occurred locally (Nørgaard et al. 2023, 136–137). Interestingly, a smaller group, including two Fårdrup axes, represents early evidence of the influx of copper from the Alto Adige Trentino-Veneto (AATV) ore district in the Italian Alps. J. Ling et al. (2023) included 18 shaft-hole axes – eleven of the Fårdrup and seven of the Valsømagle type from sites in Denmark, Norway and Sweden – in their study[4]. The two axe types form distinct clusters (Fig. 8). Some Fårdrup axes were identified as being made of copper from Mitterberg and Slovak ores; most, however, were argued to derive from the Great Orme copper mine.

Fig. 7 Fårdrup axe from Kyrkogården, Fellingsbro, Västmanland (Sweden). The axe is decorated with four arcades.

Abb. 7 *Fårdrup-Axt aus Kyrkogården, Fellingsbro, Västmanland (Schweden). Der Axtkopf ist mit vier Arkaden verziert.*

2 Junghans et al. (1974) analysed 61 axes, Liversage (2000) added three.

3 The majority of Fårdrup axes belong to SAM groups FB1–2 and FA, which are both covered by the wider FAARDMET group. Cullberg also correlated this with ornamental matrices (Cullberg 1968, 302).

4 Wrongly listed as twelve Fårdrup and six Valsømagle axes.

Collection no.	Findplace	Description	Metal type and suggested provenance	Context	Reference	Weight/ length
S 3664	Tjelta, Sola, Rogaland	Fårdrup axe, plain (patina removed)	FA/AsNi/ 6 (high tin), Mitterberg	in the ground, during ploughing	Johansen 1984	885.4 g/ 16.0 cm
B 3389	Årekol, Ullensvang, Vestland	Fårdrup axe, plain (patina removed)	B2/ungr./ 5 (medium tin), fahlore Slovak ore?	in the ground, up to a mountain (Brynefjell)	Johansen 1984	1250 g/ 17.3 cm
B 5921	Kvanngardsnes, Volda, Møre og Romsdal	Fårdrup axe, plain (cast in sand, edge damaged)	FA/AsNi/ 6 (high tin)	in the ground, c. 0,6 m deep	Johansen 1984	980 g/ 16.4 cm
T 20754	Viset, Sunndal, Møre og Romsdal	Fårdrup axe, decorated (fish-bladeemblem)	–	during flooding, in old riverbed	Engedal 2010	1729.7 g/ 17.5 cm
T 14102	Hofset, Hemne, Trøndelag	Fårdrup axe, plain, edge fragment (patina removed)	FB1/AsNi/ 6 (high tin), high Pb	in the ground, at clearance of a house foundation	Johansen 1984	–
T 14733	Lågsand, Inderøy, Trøndelag	Fårdrup axe, decorated (fish-bladeemblem)	FA/AsNi/ 6 (high tin) high Pb Great Orme	in the ground, with edge upwards, during ploughing	Johansen 1984	890 g/ 17.2 cm

Tab. 1 Overview of Fårdrup axes found in Norway. Metal and tin groups as defined by SAM (Cullberg 1968, 230–235; Junghans et al. 1974, 77–78), Liversage (2000) and Vandkilde (1996); see Fig. 10–13. Provenance ascriptions based on a combination of element and isotope analysis (Ling et al. 2023).

Tab. 1 *Überblick der Fårdrup-Äxte aus Norwegen. Metall- und Zinngruppen wie definiert in den Studien zu den Anfängen der Metallurgie (SAM; Cullberg 1968, 230–235; Junghans et al. 1974, 77–78), bei Liversage (2000) und Vandkilde (1996); vgl. Abb. 10–13. Herkunftszuschreibung anhand einer Kombination aus Element- und Isotopenanalysen (Ling et al. 2023).*

In conclusion, the majority of the 72 analysed Fårdrup axes show the low impurity pattern which is typical of the period in Scandinavia (Fig. 9). In light of this, the partly overlapping lead isotope ratios of the ores in the suggested areas of origin represent an interpretative challenge (Artioli et al. 2020; Killick et al. 2020). This is further complicated by the fact that lodes in Mitterberg, the Great Orme, and the AATV and Slovak mining regions exhibit a similar relationship between nickel and arsenic (Nørgaard et al. 2023). Do the different conclusions regarding areas of origin reflect, first and foremost, the differences in opinion about how the data are best interpreted, or were there actual regional differences across Scandinavia in terms of metal supplies? The comparison of analysed metalwork from Scandinavia c. 1600–1700 BC in Fig. 9 seems to indicate that there were in fact regional differences, where the Danish dataset leans more strongly towards Mitterberg (Nørgaard et al. 2021).

Regional patterns

Malmer (1989) observed patterned correlations between weight, shape, and ornamentation in the Fårdrup axe assemblage, and he argued on this basis for the existence of several different weight systems in the Nordic region, which were controlled by local chiefs. Sweden north of Scania has the largest number of ornamented axes (80 %), and these were argued to be imports from the assumed core area in Zealand and Schleswig-Holstein on the basis of similarities in weight and ornamentation. Malmer was careful to point out that weight and ornamentation need not overlap. He did not, however, address the slight variations in metal composition across the Nordic zone, observed by Cullberg (1968).

The six axes from Norway (Johansen 1984) may serve to exemplify a not yet clearly understood regional pattern with a strikingly northern distribution (Tab. 1). With two exceptions, the Fårdrup axes from Norway form a group of their own due to their mostly low weights (< 1000–900 g) (Malmer 1989, Fig. 4). Despite weight variations, the Norwegian axes show rather uniform lengths of between c. 16.0–17.5 cm. An unornamented axe from Årekol, Vestland (Norway; Fig. 10) falls within Malmer's weight-cluster of 1200–1450 g and an assumed centre of production in Jutland. Another axe from Viset, Møre og Romsdal (Norway; Fig. 11), decorated with a variant of the fish-blade emblem and arcades, and with a weight of 1730 g, matches better with axes from Zealand. However, the decoration of this axe differs from similarly heavy axes of the Fårdrup family in Zealand in that it has only four arcades.

The number of axes in Norway and Sweden is small compared to Denmark, and there are fewer lead isotope data points. Early on, elemental analysis of a decorated Fårdrup axe from Lågsand suggested a tin value of c. 10 % and a remarkably high lead (2.70 %) and arsenic (1.85 %) content (Cullberg 1968, 160). Cullberg (1968, 286; 290–291) stressed the link between the unusual geochemistry and high tin contents, which, he argued, mostly characterised the unornamented Fårdrup axes in Sweden. On a similar note, Ø. Engedal (2010; 2012) argued in favour of a connection via Uppland to a centre of production in Scania for the Lågsand axe and two other Norwegian specimens with high tin. A new analysis confirmed the high tin content, but

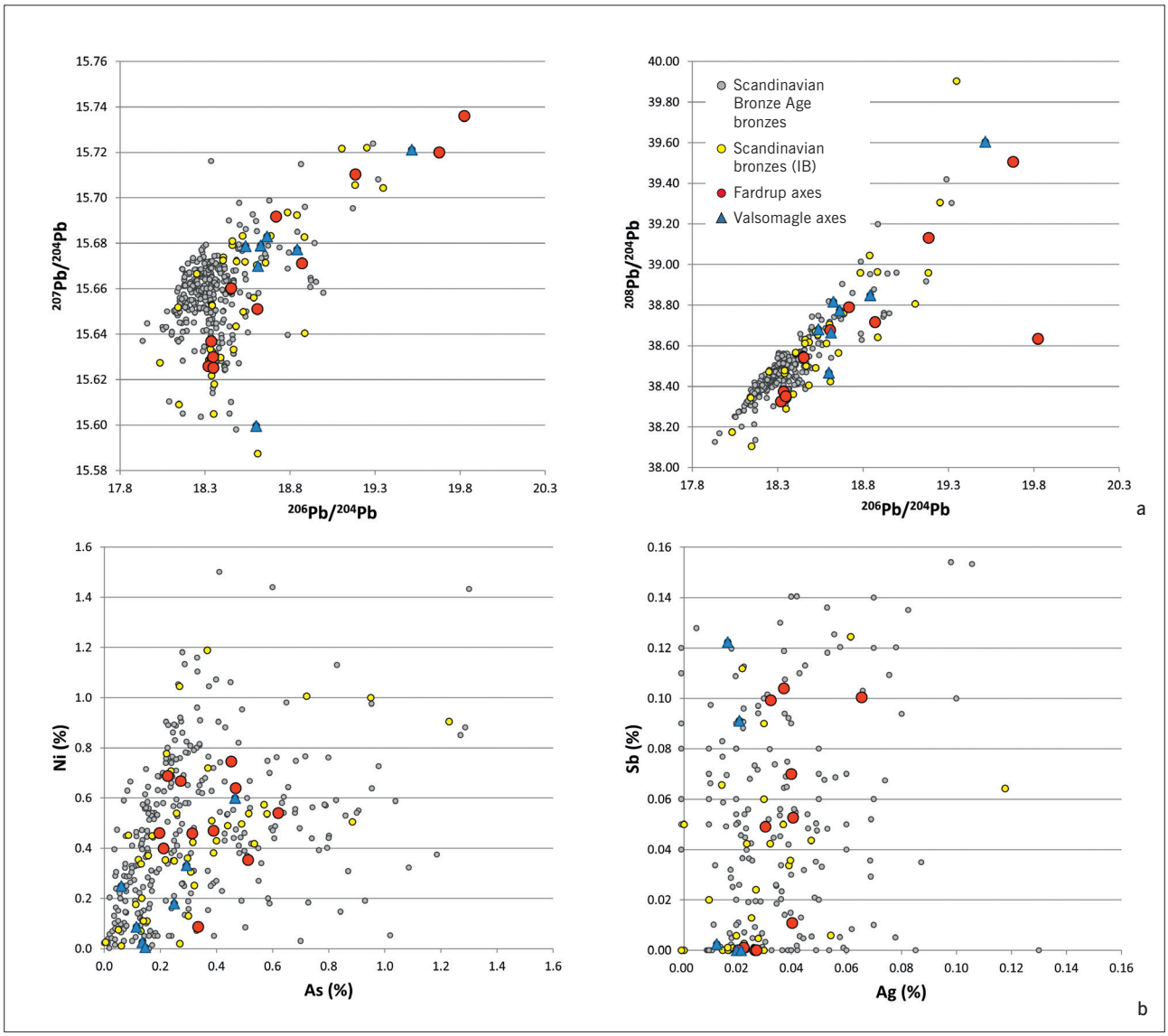


Fig. 8a–b Plots showing how Fårdrup and Valsømagle axes form clusters isotopically (a) and chemically (b) with other metalworks from Scandinavia. A cluster of altogether four Fårdrup axes (red dots) at the lower end of the isotope plots includes the axe from Lågsand, Ytterøy, Trøndelag (Norway), and the swords (yellow dots) from Dystrup, Jutland (Denmark).

Abb. 8a–b *Grafische Darstellungen von Bleiisotopen- (a) und chemischen (b) Verhältnissen der Fårdrup- und Valsømagle-Äxte mit weiteren, verwandten Metallarbeiten. Ein Cluster von insgesamt vier Fårdrup-Äxten (rote Punkte) am unteren Ende der Isotopendiagramme umfasst die Axt aus Lågsand, Ytterøy, Trøndelag (Norwegen), und die Schwerter (gelbe Punkte) aus Dystrup, Jütland (Dänemark).*

showed lower contents of lead (0.43 %) and arsenic (0.51 %; Ling et al. 2023), thus consistent with other Fårdrup style axes in the SAM dataset, with relatively high levels of lead (Liversage 2000, 74–75). With its fish-blade emblem on the front and bow decoration along the edges (Fig. 12), the design of the Lågsand axe is similar to the small Fårdrup axe, but less well executed and with idiosyncratic and unparalleled elements (Cullberg 1968, 298–299). Malmer (1989) considered the northernmost axes in Norway and Sweden to be imports from Denmark or Germany. Engedal, however, pointed out that a tin content at 10 % is incompatible with the narrow ranges of the Danish Fårdrup metal (Engedal 2010, 90). This needs to be balanced against new measurements indicating that a small group of axes from Denmark/Germany have tin of >10 % (Nørgaard et al. 2023). Most, however, fall within a tin range of 6.5–9.6 %. At the other end of the scale are a couple of Swedish axes with tin at only 4.0–4.3 % (Ling et al. 2023).

Isotopically, the Lågsand axe conforms with most other Fårdrup axes from the Scandinavian Peninsula (Ling et al. 2023), and plots closely with three other axes and the Dystrup swords (Fig. 8a). The axe from Årekol stands out: It is possibly made of a fahlore copper of Slovak origin. The copper of the inconspicuous axe from Tjelta (Fig. 13) with high tin but low lead is interpreted as coming from Mitterberg. The heightened lead content in some Fårdrup axes may indicate co-smelting with galena, a practice recognised in British metalwork during the Acton Park phase (c. 1500–1300 BC; Northover in Melheim 2015, 68) and possibly related to the lead vein crossing the copper veins at Great Orme (Williams/Le Carlier de Veslud 2019). Currently, the Great Orme mine is considered an important contributor of

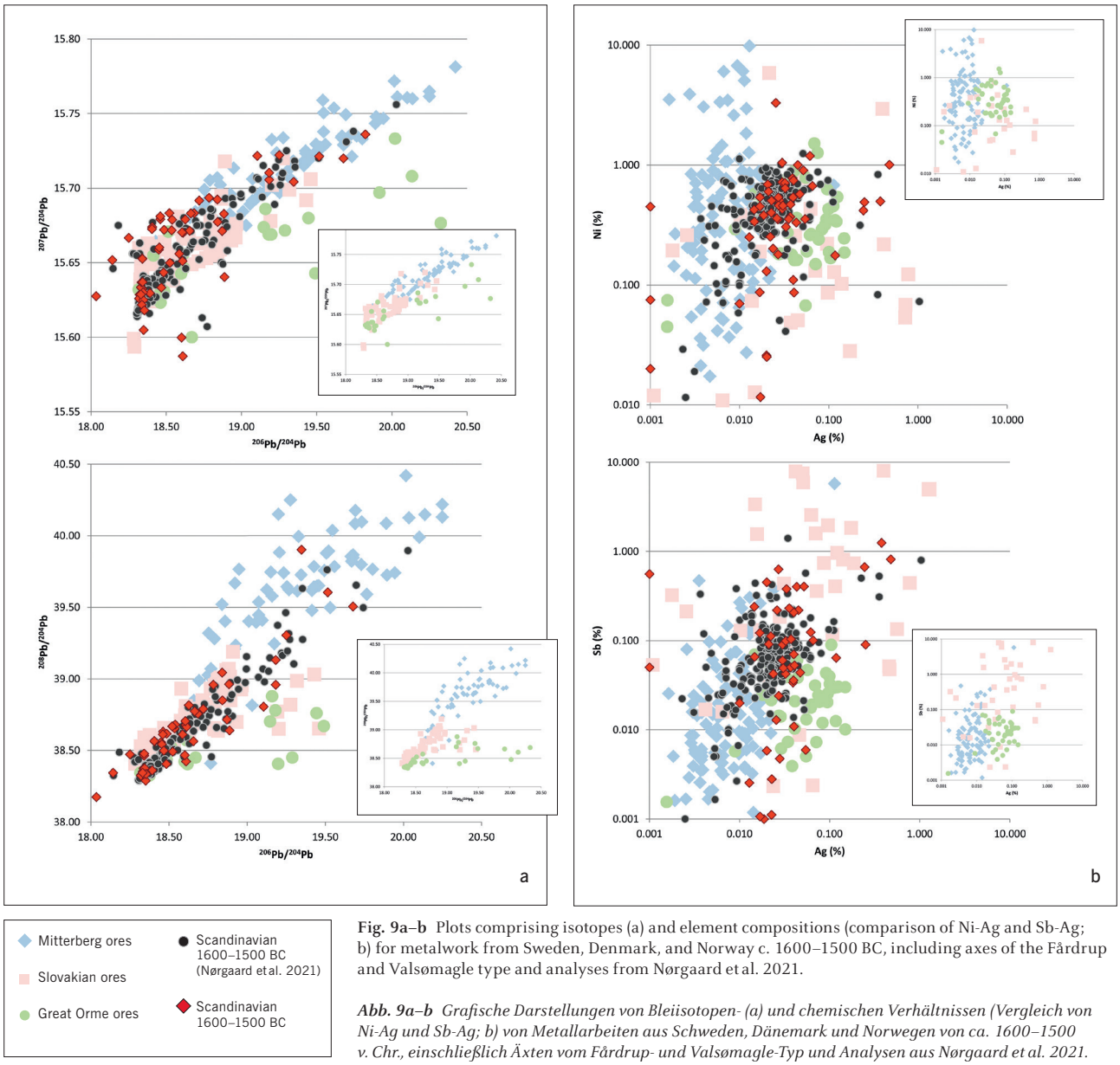


Fig. 9a–b Plots comprising isotopes (a) and element compositions (comparison of Ni-Ag and Sb-Ag; b) for metalwork from Sweden, Denmark, and Norway c. 1600–1500 BC, including axes of the Fårdrup and Valsømagle type and analyses from Nørgaard et al. 2021.

Abb. 9a–b *Grafische Darstellungen von Bleiisotopen- (a) und chemischen Verhältnissen (Vergleich von Ni-Ag und Sb-Ag; b) von Metallarbeiten aus Schweden, Dänemark und Norwegen von ca. 1600–1500 v. Chr., einschließlich Äxten vom Fårdrup- und Valsømagle-Typ und Analysen aus Nørgaard et al. 2021.*

low-impurity copper of the AsNi type. This is indeed interesting in light of the fact that the British Isles was also a key source of tin, a crucial factor in the circulation of bronze. Analysis of one axe from a hoard of two shield-patterned palstaves at Hönö, Västra Götaland (Sweden), shows consistency with Great Orme copper and has a tin content of 9.3 %[5]. Already from c. 2000 BC, the British Isles delivered high-tin copper to Southern Scandinavia (Vandkilde 2017, 174–175), and tin exportation may have increased when production at Great Orme peaked c. 1600–1400 BC (Williams/Le Carlier de Veslud 2019).

A scenario where tin arrived in Scandinavia already alloyed with copper from Britain and was then mixed with copper from other sources, may explain the mixing lines in the isotope plots and support the theory that the Fårdrup axes were recast from already alloyed metal at local workshops. Was the mixing of batches of low impurity copper from different suppliers, with and without tin, perhaps an intentional act aimed at creating particular metal qualities?

Nørgaard et al. (2023) identified regional patterns in the Danish dataset between metal supplies and local workshops. Here, axe metal of possible British or Welsh origin seems to scatter along an axis from Jutland to the Danish Isles and coastal parts of Northern Jutland and Germany. The overlap between Fårdrup axe metal and the Dystrup swords when it comes to metal type, alloy, weight and ornamentation is striking. To what degree axe metal correlates with regional metalworking traditions more broadly, for instance whether Fårdrup axe metal is reflected in other metalwork of Fårdrup style, must be a topic for future stud-

5 Williams/Le Carlier de Veslud 2019; cf. Ling et al. 2014, who argued for a Greek origin of the copper.

Fig. 10 Fårdrup axe from Årekol, Ullensvang, Vestland (Norway) from all four sides.

Abb. 10 *Fårdrup-Axt aus Årekol, Ullensvang, Vestland (Norwegen) von allen vier Seiten.*

ies. Suffice it here to point to possible correlations between axe metal and distribution chains for bronze.

D. Fontijn and J. Roymans (2019) argued in a discussion of palstave hoards that such serially produced, yet differently styled axes can be understood as regional brands. Their value was related to their ›axe-affordance‹, that is, the capacity to be transformed into functional axes. In light of the theory that axe hoards relate to trade, one could assume that hoards with several Fårdrup axes can shed further light on the regional circulation of metal. According to Malmer (1989), the nine axes in the Bregninge hoard from Højsted in Zealand could be split into two groups based on weight standards and surface finish (decorated versus plain). Despite this fact, and with one exception, the Bregninge axes form a tight cluster both chemically and isotopically (Nørgaard et al. 2023). Two of the decorated axes which occurred together at Bækbølling in south-western Jutland show a high degree of chemical overlap and similar

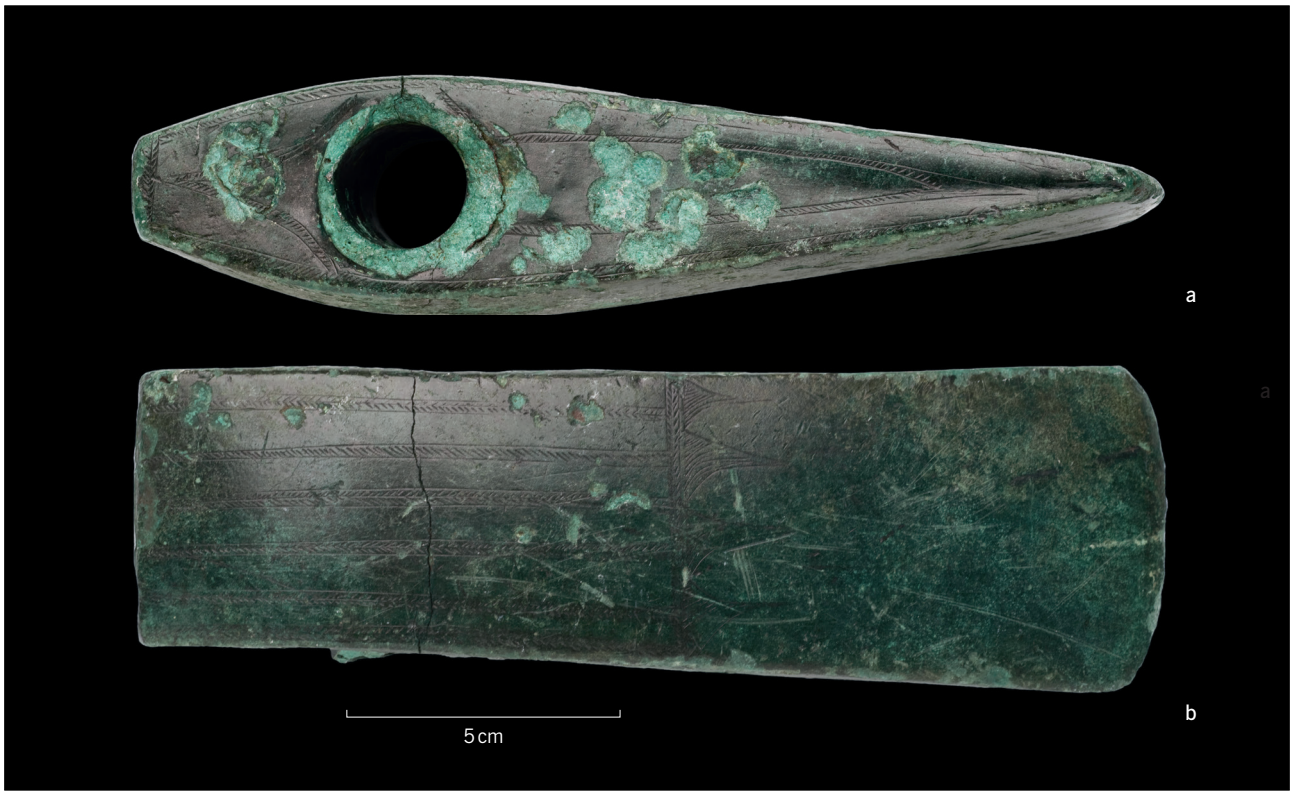


Fig. 11a–b Fårdrup axe from Viset, Sunndal, Møre og Romsdal (Norway). The front of this axe (a) is decorated with a variant of the fish-blade emblem; the side has four arcades (b).

Abb. 11a–b *Fårdrup-Axt aus Viset, Sunndal, Møre og Romsdal (Norwegen). Die Vorderseite dieser Axt (a) ist mit einer Variante des Fisch-Klingen-Motivs verziert, die Seite mit vier Arkaden (b).*

Fig. 12a–b Fårdrup axe from Lågsand, Ytterøy, Trøndelag (Norway). This axe has a fish-blade emblem on the front side (a) and bow decoration along the edges, very similar to the small axe in the Fårdrup hoard. The side (b) shows severe damage.

Abb. 12a–b *Fårdrup-Axt aus Lågsand, Ytterøy, Trøndelag (Norwegen). Diese Axt weist auf der Vorderseite (a) ein Fisch-Klingen-Motiv und Bögen an den Rändern auf, die denen der kleineren Axt aus dem Fårdrup-Hort sehr ähneln. Die Seite (b) ist stark beschädigt.*

Fig. 13a–b Plain Fårdrup axe from Tjelta, Sola, Rogaland (Norway), from the front (a) and the side (b).

Abb. 13a–b *Unverzierte Fårdrup-Axt aus Tjelta, Sola, Rogaland (Norwegen), von vorne (a) und von der Seite (b).*

tin contents (c. 7–8 %) yet belong to different isotope groups. The third axe plots with one of the other two isotopically, but has a somehow different elemental composition and very high tin content at 11.5 %, which is comparable instead with a group of axes from Lolland and Mecklenburg (Nørgaard et al. 2023). There are, in other words, no obvious patterns to be found among the axes hoarded together that allow us to directly connect raw material, alloy, weight, and ornamentation. However, a co-presence of axes of different brands in the later palstave hoards were interpreted as an integral part of the economy of circulation and the ritual practices related to it (Fontijn/Roymans 2019).

The role of weight-regulated artefacts

Current knowledge about how metal transactions were organised in the north during the Early Bronze Age is based on circumstantial evidence. Hubs for metal importation have been located from c. 2000 BC and are characterised, among other things, by accumulations of hoards (Vandkilde 2017, 169–172). During the timespan of 1600–1500 BC, the quantity of imported artefacts was extremely low compared to locally crafted objects (Vandkilde 1996, 246 Fig. 266), indicating that imported metal was melted or recast from ingots, preforms, or scrap. This transformation is likely to have occurred at central sites where metal coming in from the outside was pooled and reworked. It has been hypothesised that, during the Late Bronze Age and perhaps already from c. 1500 BC, coastal workshop sites in the Nordic realm functioned as early ports of trade: as landing areas and market places where metal was transformed into a regionally acceptable value system (Melheim 2018). Pooling and remelting can explain the variation of sources identified through provenance analysis and possibly also the mixing of metal from various sources (Berger et al. 2022).

By extending his analysis to Late Bronze Age (c. 1100–500 BC) evidence – including, among other things, a group of enigmatic figurines, the so-called goddesses of wealth – Malmer (1992) further developed his ideas about a Nordic weight unit. These were then fine-tuned by E. Sperber (1993), who used statistical calculation to identify a core unit of 26.6 g, which, he argued, was convertible to other Eurasian units and enabled participation in interregional trade. Identifying this unit in a newly discovered figurine of the ›goddess of wealth‹ type from the Tollense Valley, Mecklenburgische Seenplatte district (Germany), T. Terberger et al. (2022) stressed the difference between a weight and a weight-regulated artefact, the latter meaning that an item is produced from a measured amount of metal, not that it is itself a weight. The application of balance weights in Bronze Age Europe was closely linked to the global trade in metals and textiles (Vandkilde 2021). Still, the idea of a common Eurasian unit does not withstand a systematic comparison of weighing equipment and weights, indicating instead that many different local units existed simultaneously (Ialongo/Rahmstorf 2019).

Fontijn and Roymans (2019) argued that shape was more important than weight in the constitution of axe brands during the Middle Bronze Age. In the same line of thought, M. Kuijpers and C. Popa (2021) introduced per-

ceived similarity of weight as a factor in Early Bronze Age Europe. They argued, on the basis of weight equivalence between rings, ribs, and axes, that a weight-based system evolved prior to the use of balance weights: »The material medium – bronze – helped to move this conceptual innovation along because it afforded an unprecedented sameness between objects [...] Since human cognition is a dynamic system that includes mind, body and material forms, thinking through these objects helped scaffold the cognitive framework that is needed for the development of a weight unit« (Kuijpers/Popa 2021, 10). They also argued that axes were local economic articulations that bridged the gap between different economic systems when they circulated outside the core areas of rings and ribs. This may be extended to the Fårdrup axes and their role in a prestige goods economy with increasing commodification (Kristiansen 2007). Although the northerners were late in adopting balance weights – not until 1200 BC and possibly as late as 800 BC (Ialongo/Rahmstorf 2019 Fig. 1) – this does not mean that they were unacquainted with weight systems as such. I contend therefore that the Fårdrup axes were local economic articulations: weight-regulated artefacts in a system based on perceived weight.

While recent discussions based on combined lead isotope and elemental analysis leave us with a complex or rather chaotic image of metal circulation, we must assume that, in Bronze Age exchange situations, the customers would be interested in being able to assess the quality of the metal and to evaluate the capacity of the preform. I have argued that the Fårdrup axes represented metal values aimed at one or several different regional markets within Scandinavia and that they were decorated according to a sign system which contained codes for metal quality, axe brands representative of regionally established values, yet committed to a Nordic canon and the same broad visual script. Possibly, the quite homogenous tin ranges may suggest that certain metal qualities were considered optimal for the casting of 16th century BC innovations such as the sword. I have hypothesised, therefore, that the fish-blade emblem may refer to ›blade quality metal‹.

Conclusions

This article is a small contribution to ongoing discussions, adding provenance discussions based on lead isotopes to the many variables which constituted regional value systems in the north from 1600–1500 BC. What has interested me most is how values are being created, legitimised, and negotiated through material expressions and citations, and how values tend to be authorised by being anchored in the past. Axe currencies were an invention of the Stone Age that survived the transition from stone to bronze and continued far into the Iron Age and beyond. Modifying previous interpretations, I have argued, that the Fårdrup axes of c. 1600–1500 BC are best understood not as weights, but as weight-regulated artefacts. They were an intermediary between ingot and artefact, an already alloyed preform (bronze ingot) to be recast. In conclusion, the Fårdrup axe was not a functional axe, but a tool for value and a container of wealth, and hence perhaps best described as an axe currency, which could move easily between economic, social, and ritual spheres. I have focused the discussion on the Fårdrup axes, but the interpretation can be extended to cover other contemporary axe types: for instance, the Valsømagle axes.

Following transactions across cultural borders, a transformation of value may occur, for example, through the selective adoption of certain elements from another tradition, just as we saw with the Fårdrup axe script referencing symbols from Carpathian metalwork. Although building on a Carpathian script, these axes borrowed their legitimacy from their direct predecessor, the simple shaft-hole axe of stone. They were craft products local to the Nordic Bronze Age, cast with metals from various ore regions, and alloyed and ornamented according to regional standards. In this way, imported metal was being transformed into one or several Nordic value systems. I have hypothesised that the decoration contained information about what the preform could be used for. The differences seen across Scandinavia in weight, ornamentation, and alloying patterns may be representative of branding at certain regional workshops from which metals and other trade goods were redistributed.

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Chemical and isotopic composition of Bronze Age Axes from the north-west of France

Cécile Le Carlier de Veslud and Sidonie Révillon

Zusammenfassung

Chemische und isotopische Zusammensetzung von bronzezeitlichen Äxten aus Nordwestfrankreich

Der Nordwesten Frankreichs verfügt über wenige und womöglich schwache Kupfervorkommen. Überraschenderweise ist er jedoch auch eine derjenigen französischen Regionen, in denen chalkolithische bis endbronzezeitliche Metallobjekte, darunter viele Beile, in sehr großer Zahl in Gräbern der Frühen Bronzezeit und in Metallhorten ab der Mittleren Bronzezeit 1 vorkommen. In den frühesten Zeitabschnitten handelt es sich bei sehr vielen Beilen um Einzelfunde, sodass es fast unmöglich ist, sie in einen konkreten Kontext zu bringen.

Die vorliegende Untersuchung stellt eine chronologische Übersicht der Forschung zu Beilen und ihrer Typologie dar – mit einem Fokus auf die Ergebnisse der chemischen Element- und Isotopenanalysen. Obwohl in den frühesten Perioden möglicherweise einige armorikanische Vorkommen zur Herstellung von Artefakten genutzt wurden, wurde Kupfer eindeutig bereits in der Frühen Bronzezeit importiert. Bis zur Mittleren Bronzezeit 1 scheint das Metall zunächst aus den Vorkommen an der Atlantikküste zu stammen. Ab der Mittleren Bronzezeit 2 kam es dann offenbar aus anderen Regionen. Ab der Späten Bronzezeit 2 ist eine Vielzahl möglicherweise auch weiter entfernter Quellen aus den chemischen Signaturen der Artefakte, wie Beile und Kupferbarren, erwiesen.

Schlagworte Armorikanisches Massiv, Kupferbeile, Bronzebeile, Bronzezeit, chemische Elementanalyse, Isotopenanalyse

Summary

The north-west of France is a region where copper deposits are rare and perhaps poor. Surprisingly, it is also one of the French regions where metal objects, including a large number of axes dating from the Chalcolithic period to the end of the Bronze Age, have been found in very large numbers in tombs of the Early Bronze Age period and in metal hoards from the Middle Bronze Age 1 onwards. For the earliest periods, very large numbers of axes have been found in isolation, which presents an almost insoluble problem of putting them back into context.

The aim of this study is to provide a chronological overview of research into axes, with a brief review of their typology. The study focuses on the knowledge of the nature of the metal through elemental chemical and isotopic analyses. While it is possible that some Armorican deposits may have been used to produce artefacts in the earliest periods, it seems clear that copper was imported as early as the Early Bronze Age. Initially, the metal seems to have come from deposits in »Atlantic« countries, until the Middle Bronze Age 1. From the Middle Bronze Age 2 onwards, the copper seems to have come from other regions. From the Late Bronze Age 2 onwards, a diversity of sources, some of which may be distant, seems evident, as can be seen from the chemical signatures of objects, including axes and copper ingots.

Keywords Armorican Massif, copper axes, bronze axes, Bronze Age, elementary chemical analyses, isotopic analyses

Introduction

For several decades, the archaeometrical research has tried to determine the origin of raw materials used to produce copper-based metal artefacts, firstly by chemical analyses, then by isotopic ones. This research has been carried out in almost all countries in Europe[1]. In France, for instance, examples of such studies are the works of Rennes University from 1960 to 1990 (such as Briard/Bourhis 1984; Bourhis/Briard 1985), as well as the works of the Centre de Recherche et de Restauration des Musées de France (C2RMF)-team (Paris; such as Mille/Bourgarit 2000), which are still in progress. From 2007, a new research program of chemical analyses has been initiated at Rennes, and from 2017 some LIA analyses (Lead Isotopic Analyses) have been realised dealing with the north of France, including Brittany, Normandy, Loire, and regions of Central France have been carried out under the direction of the author. Studies of artefacts from other French regions have also been performed, enabling comparisons to be made over greater distances.

In the north-west of France, a large number of Bronze Age metal objects have been discovered, mainly in ter-

1 For example, Höppner et al. 2005; Dolfini et al. 2020; Nørgaard et al. 2021; Berger et al. 2023; O'Brien 2023; Williams 2023.

2 Briard 1965; Milcent 2012; Nordez 2019; Bordas 2023.

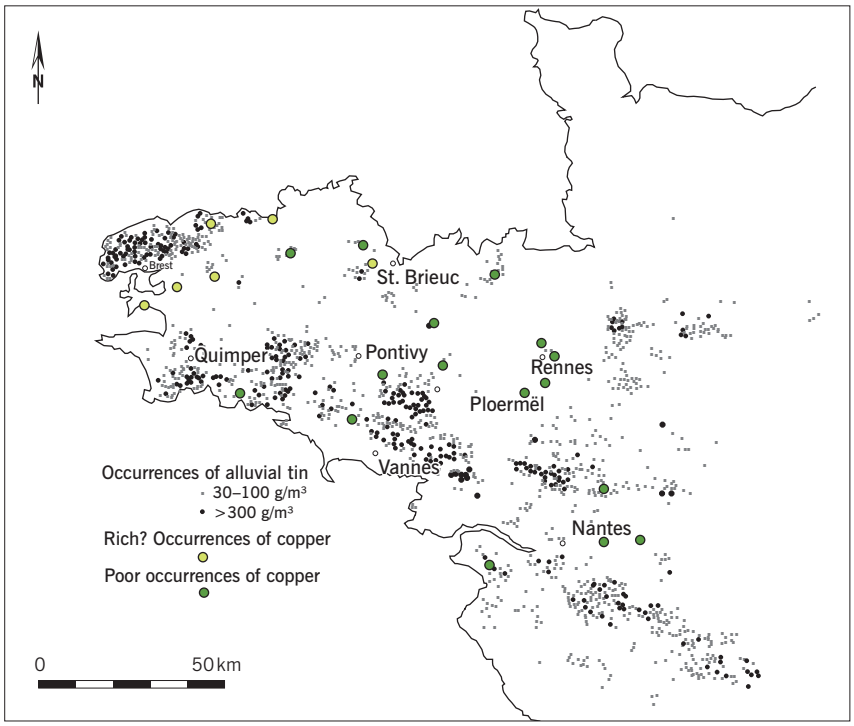


Fig. 1 Distribution map of alluvial cassiterite and copper occurrences in the Armorican Massif.

Abb. 1 *Verbreitungskarte alluvialer Kassiterit- und Kupfervorkommen im Armorikanischen Massiv.*

restrial hoards[2], but also in river beds (Mélin 2011) and in graves (Nicolas 2016), as well as isolated finds without any known context (Gandois 2018). In the latter case, it was mainly axes that were found, most of which can probably be attributed to the Chalcolithic period, although a minority can be linked to the more recent Bronze Age.

The main question that arises in this western region concerns the copper origin. Armorican deposits contain some evidence of copper, but the most occurrences encountered are not recognised as significant deposits by modern geologists, except perhaps one sector located in northern department of Finistère (Marcoux 2017). However, while some areas may have been rich enough to be considered as small deposits and allowing the production of artefacts in the earliest periods, it is clear that, at some point, given the size of the mass of metal needed for all the known artefacts, copper in metallic form has to be imported from other regions of France or Europe.

Copper resources in the Armorican Massif

The geological context of north-western France corresponds, for a very large part of the territory, to the Armorican Massif, whose latest major tectonic movements occurred during the Hercynian orogeny (400–300 Ma; Ballèvre et al. 2009). The terrain currently visible therefore corresponds to an ancient, now-eroded mountain belt, with numerous gold, tin, and lead deposits, but very little copper (Fig. 1; Marcoux 2017). Nevertheless, copper occurrences were observed by geologists at various points in Brittany in the early 19th century (Kerforne 1926) and then later during intensive geological surveys between the 1960s and 1990s by the BRGM (Bureau de Recherche Géologique et Minière, the French Geological Survey, Orléans). These are essentially polymetallic sulphide mineralisations of the BGPC (Blende-Galena-Pyrite-Chalcopyrite) type. Chalcopyrite is usually speckled with other minerals, but may also be present as veinlets (Pierrot al. 1973; Pierrot et al. 1975). Fahlore could be also observed. Meteoric alteration zone is generally non-existent due to the acidity of the soils and the high rainfall. However, a few sectors did show some covellite and, much more rarely, malachite (Robert 1970; Chauris et al. 1976). The quantities of these oxidised minerals are quite small. However, it is very difficult to determine the exact quantity of copper minerals in these deposits, as the descriptions made by geologists are often vague, using terms such as »rich,« »rare,« and »very rare.« In a region where copper is rare, one sector may be described as »rich« because it is exceptional in the regional context, although it is not a major deposit. Six sectors may nevertheless have contained copper in sufficient quantities to enable small-scale copper mining operations to be carried out. Unfortunately, three sectors were intensively mined in modern times, destroying any areas that might have shown signs of earlier mining: Lanmeur (Finistère) for associated tin (Robert 1970), and Huelgoat (Finistère), and, to a lesser extent, Trémuson (Côtes d'Armor) for galena (Chauris et al. 1976). A fourth sector (Carnoët, Finistère) is currently under archaeological investigation; here, a very small copper mine was exploited in the 18th century (Mulot 1984), and it is possible that some malachite may still be found. Unfortunately, for the moment no archaeological evidence of prehistoric mining has been found and no prehistoric mining tools have been discovered in connection with possible copper mining.

Analytical methods

In an attempt to characterise the origin of the copper, the analyses program of copper-based artefacts was relaunched

in Rennes fifteen years ago, initially using elementary chemical analyses by Horiba ICP-OES (Ultima Expert). Samples were taken with a micro-drill from the sound metal after stripping of the weathered surface layer, enabling 40 mg of metal to be taken, leaving a surface impact of around 1 mm.

These types of analyses provide accurate values for trace elements, making it possible to highlight chemical signatures for artefacts of the same chronology in certain geographical areas. The analysis protocol is based on that of B. Mille and D. Bourgarit (2000) and is fully described in Aranda et al. (2013). Alloying elements are given in % (calculated from concentration in mg/l), and trace elements in ppm (10 000 ppm = 1 %). Correlations between alloying elements and trace elements (Ag, As, Ni, and Sb), and between the trace elements themselves, are visualised using binary diagrams. Ternary diagrams can also be used for a better visualisation of the results. These elemental analyses reveal compositional groups that may reflect the type of metal used in a given region for a given period. This can also reveal possible recycling and mixtures of metals of various origins when a large number of objects are analysed. It is on the basis of these results that the objects that will benefit from isotopic analyses should be selected. Since 2017, lead isotope analyses have been initiated and realised in SEDISOR/GEO-OCEAN in Brest, Finistère, and they follow the method described in a previous article (Couderc et al. 2021). Unfortunately, isotopic results have not yet been fully processed. The reference database of known copper deposits is not complete, and there are many unknown or as yet unanalysed deposits that could modify interpretations. The diagrams presented here also lack precision and concern only the representation of $^{206}Pb/^{204}Pb$ vs $^{207}Pb/^{204}Pb$. For hypotheses, the $^{208}Pb/^{204}Pb$ value has been also taken into account. As a result, the main outcome of the present study is to rule out some origins rather than determining precise ones. The few hypotheses put forward cannot therefore be taken as definitive results and further studies are needed.

Context and chronology of the Bronze Age in north-western France

The area covered by this study is Atlantic Europe, whose various definitions are based on the frequency of appearance and associations of types of metal production and specific cultural features (Milcent 2012). Today, the existence of a cultural Atlantic Europe domain is no longer really debated, but its limits and the internal dynamics that drive it are still debated (Bordas Moran Dupuch 2023). For P. Y. Milcent (2012), Atlantic Europe can be seen as »the image of a living, fairly fluid mechanism based mainly on the circulation of goods, people and ideas along the Atlantic coasts and within the lower basins of the main rivers that flow into them, on a scale that goes beyond community frameworks.«

As with the delimitation of territories, chronological limits are based essentially on the typology of bronze objects, most often found in metal hoards from the Middle Bronze Age onwards, as well as their frequency of appearance and association (Fig. 2). Axes, although not the best master artefacts, can contribute to this delimitation. However, the typological and/or chronological attributions of certain axes, particularly for the Middle and Late Bronze periods, need to be revisited in the light of the analytical studies, as we shall see below in the case of »Rosnoën« type axes.

Before the Middle Bronze Age, the chronological and cultural attribution is based on the material found in the many burial mounds in north-western France as well as on the

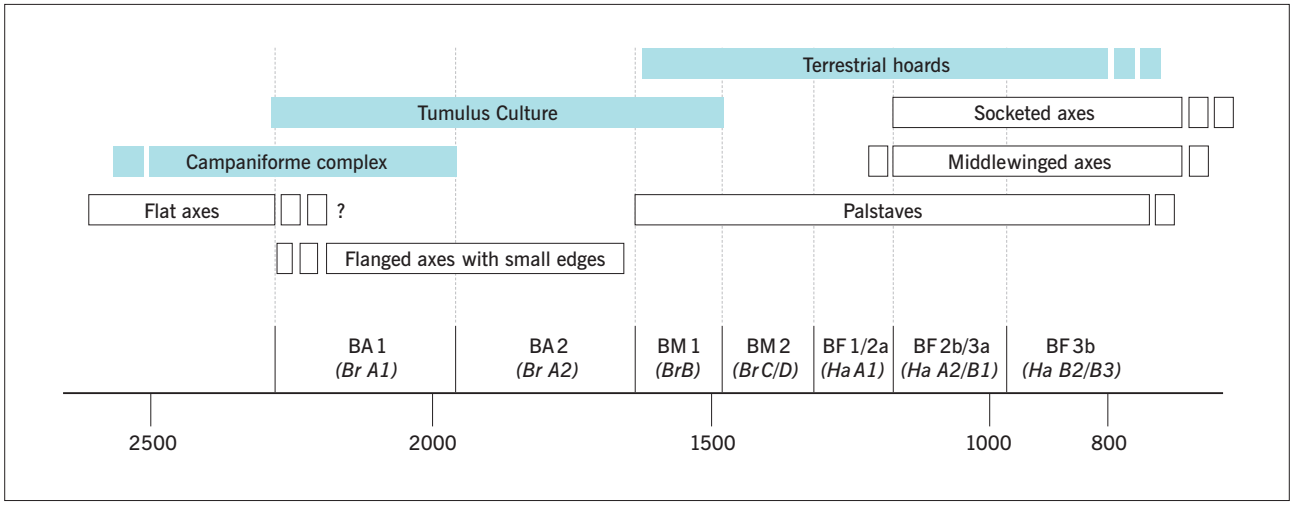


Fig. 2 Chronology of the Bronze Age in north-western France and probable dating of axe type production. For the Atlantic domain: A-EBA 1 = Atlantic Early Bronze Age 1; A-EBA 2 = Atlantic Early Bronze Age 2; A-MBA 1 = Atlantic Middle Bronze Age 1; A-MBA 2 = Atlantic Middle Bronze Age 2; A-LBA 1/2a = Atlantic Late Bronze Age 1/2a; A-LBA 2b/3a = Atlantic Late Bronze Age 2b/3a; recent A-LBA 3 = recent Atlantic Late Bronze Age 3. For the continental domain: Br A1 = Bronze Age A1; Br A2 = Bronze Age A2; Br B = Bronze Age B; Br C/D = Bronze Age C/D; Ha A1 = Hallstatt A1; Ha A2/B1 = Hallstatt A2/B1; Ha B2/B3 = Hallstatt B2/B3.

Abb. 2 *Chronologie der Bronzezeit in Nordwestfrankreich und mögliche Datierung der Herstellung unterschiedlicher Beilformen. Für den atlantischen Bereich: A-EBA 1 = Atlantische Frühbronzezeit 1; A-EBA 2 = Atlantische Frühbronzezeit 2; A-MBA 1 = Atlantische Mittelbronzezeit 1; A-MBA 2 = Atlantische Mittelbronzezeit 2; A-LBA 1/2a = Atlantische Spätbronzezeit 1/2a; A-LBA 2b/3a = Atlantische Spätbronzezeit 2b/3a; rezente A-LBA 3 = rezente Atlantische Spätbronzezeit 3. Für den kontinentalen Bereich: Br A1 = Frühbronzezeit A1; Br A2 = Frühbronzezeit A2; Br B = Mittlere Bronzezeit B; Br C/D = Mittlere Bronzezeit C/D; Ha A1 = Hallstatt A1; Ha A2/B1 = Hallstatt A2/B1; Ha B2/B3 = Hallstatt B2/B3.*

pottery found in settlements where metal remains are virtually non-existent. As a result, a number of artefact types, including axes, have been attributed to the Early Bronze Age. Unfortunately, many uncertainties remain, as most of the burial mounds known in the literature were excavated at an early date, so there is no way of absolutely dating them. However, the construction of these tombs, which began in the Early Bronze Age, seems to have continued for some time into the Middle Bronze Age. Some of the tombs also appear to have been reused or rebuilt well into the Bronze Age (Nicolas 2016), further disrupting the interpretation of these buildings. Finally, what really limits the chrono-typological study of axes produced before the Middle Bronze Age is their discovery in isolation in the ground, without any archaeological context.

The earliest known copper objects in north-western France have been dated to the 4th millennium. These are isolated axes with a completely different typology to those known from other periods, similar to axes known in Eastern Europe (Klassen et al. 2017). Metal, found in the form of beads and awls, really appeared at the end of the Neolithic period (Van der Linden 2006). The Artenacian Culture (central-western France) probably played a major role in the production and perhaps the spread of copper (Mille 2010). But it was very likely in the Bell Beaker context that more developed production appeared, with the manufacture of beads and awls as well as small daggers and Palmela heads (Van der Linden 2006). Most of the flat axeheads discovered without context can probably be attributed to this period. In fact, copper flat axeheads are widely found in the two main regions of France where other copper artefacts were also found in this period, namely, the south-eastern Mediterranean and the north-western regions (Gandois 2009).

The next period is divided into two stages essentially linked to the typology of the daggers: an early stage, Br A1 (2200–1900 BC), and a more recent stage, Br A2 (1900–1650 BC). These stages correspond to those attributed to eastern France and Germany. The Middle Bronze Age can also be divided into two stages (Nordez 2019). The early stage, A-MBA 1, corresponds to the Tréboul horizon (1550–1450 BC) (Briard 1965), equivalent to H. Müller-Karpe (1959) Bronze B for Central Europe and Germany, and A-MBA 2 corresponds to that of the Moustiers horizon (1450–1300 BC) (Nordez 2019), equivalent to Br C. The chronology of the Atlantic Late Bronze Age has been reviewed by Milcent (2012) and is based on six material sequences. The first stage of the Late Bronze Age corresponds to the Rosnoën horizon and may be divided into two sub-periods: the Early A-LBA 1 (Saint-Just-en-Chaussée horizon, 1275–1225 BC), equivalent to Br D1/D2, and the Late A-LBA 1 (Chailloué horizon, 1225–1140/1125 BC), equivalent to Ha A1. The second stage corresponds to the Saint-Brieuc-des-Iffs horizon, which may also be broken down into a first stage, the Early A-LBA 2 (Rédéné horizon) between 1140/1125–1050 BC (Ha A2), and a second, the Late A-LBA 2 (Boutigny horizon) between 1050 and 950 BC (Ha B1). Finally, the last stage of the Late Bronze Age corresponds to the Plainseau horizon, once again organised into two stages: the Early A-LBA 3 (Longueville horizon) from 950 to 900 BC (Ha B2) and the Late A-LBA 2 (Vénat horizon) from 900 to 800 BC (Ha B3).

Early metallurgy, (probably) Bell Beaker Culture

In recent years, rare Bell Beaker sites with traces of copper-working have been discovered in north-western France at Talmont-Saint-Hilaire in Vendée department (Gandois et al. 2020), Oléron in Charente Maritime department (Gandois/Soler 2022), and Concarneau in Finistère (Le Gall 2023). Metalworking has been evidenced through the analysis of ceramic sherds reused in metallurgy, proving that metalworking using furnace-vessel technology could have taken place in north-western France up to the western extremity of the Armorican peninsula. As a result, the question of local metal production has been revived. But to prove this, only a major forthcoming campaign of elemental and isotopic analyses of very ancient metal objects and rare Armorican ores will provide answers.

Nevertheless, it does seem that a part of objects could have been made in these western regions, as metalworking sites do exist. But some artefacts could also be imported, just as they were in other countries (Nørgaard et al. 2021a). What type of objects could have been produced? Axes? The lack of context prevents us from answering this question. A database has been compiled containing several thousand objects from the Chalcolithic and Early Bronze periods, over 2000 of which have been analysed in the past (Gandois 2018). Many of these analyses are old and inaccurate, so elementary chemical analyses will have to be done again, in conjunction with lead isotope analyses, which are currently non-existent in the search for copper sources. The general typology of flat axeheads in France is still based on the work of J. Briard and G. Verron (1976). The variability in the shape of the axes could indicate a variety of origins (Fig. 3a). This work needs to be taken up in more detail. However, a number of recent studies combining typological studies and chemical analyses point to widespread production in central-western France (Gandois et al. 2024) and, in some cases, as far afield as eastern France (Klassen et al. 2007). While an exhaustive analytical study is still lacking, a number of flat axes, found without context, from the north-west of France have been analysed by ICP-OES at the Rennes laboratory in recent years. Regardless of the type of axe, we can see that some of the axes are made of bronze, with tin contents ranging from 1–12 % and with a low arsenic content of under 1 %. Another part is arsenic-rich copper with an arsenic content between 1–9 %. Finally, a few axes contain both tin and arsenic, but at low levels of between 1 % and 3 % for these two elements. The levels of some trace elements are highly variable, including Ni (from 0 to 40 000 ppm, median at 4000 ppm) and Sb (from 0 to 4500 ppm, median at 1000 ppm), suggesting different and perhaps distant origins. Indeed, nickel is very rarely found in Armorican peninsula deposits. The Armorican Bell Beaker Culture was probably heavily influenced by the Iberian Peninsula, and some axes may have travelled from these regions. Similarly, the south of France is very rich in flat axes (Guilaine 1972; Gandois 2009), which could also have travelled as far as the north-west of France. Finally, a local origin for the copper is always possible, but this has not yet been verified.

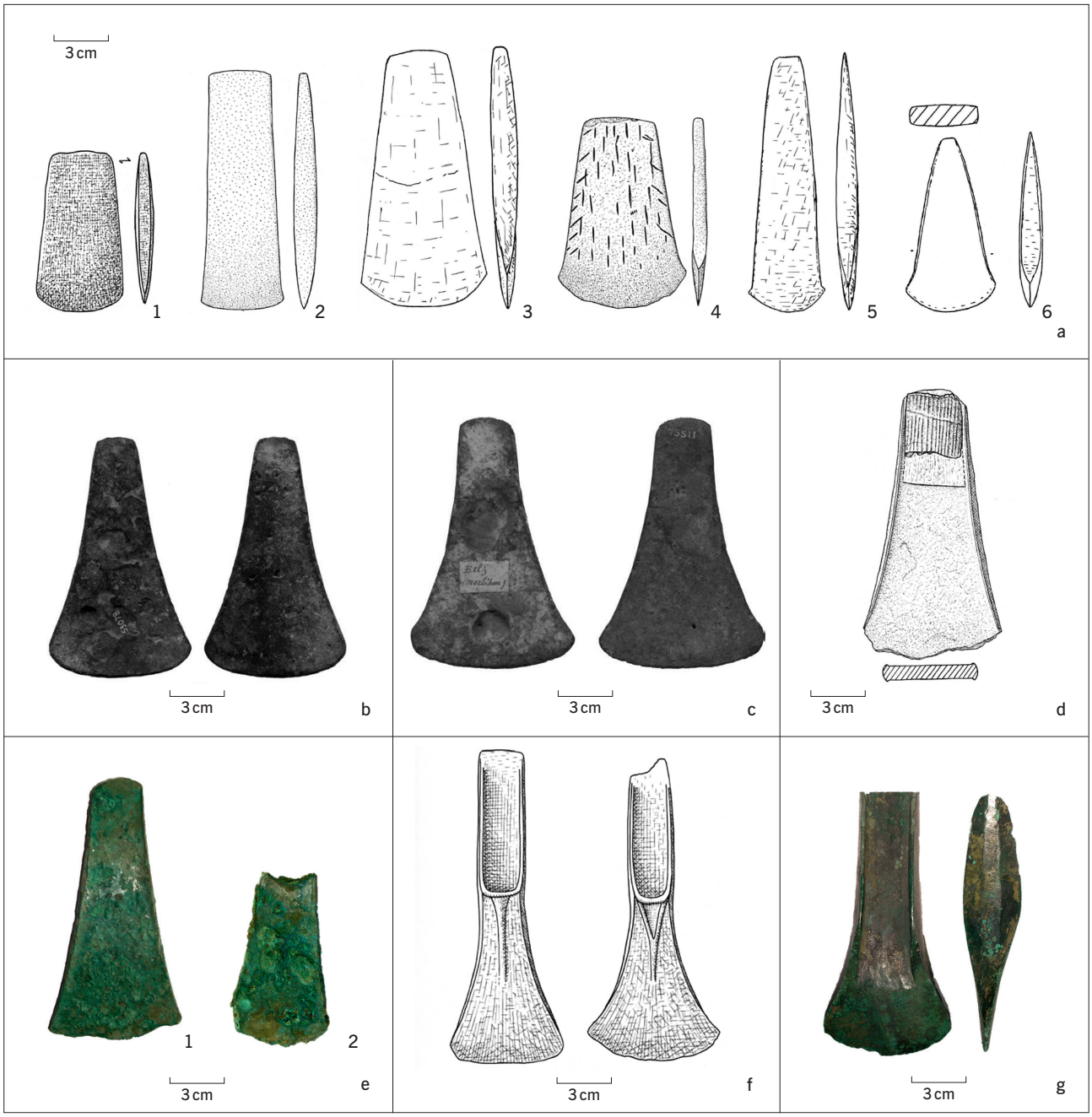


Fig. 3a–g a Flat axeheads from the Côtes d'Armor department; b Flat axehead from the Ploudaniel hoard; c Flat axehead from the Belz hoard; d Low-flanged axeheads from the Trémel tumulus; e Low-flanged axeheads from the Crec'h Perros tumulus; f Palstaves from the Tréboul hoard; g Long-flanged axehead from the Tréboul hoard.

Abb. 3a–g *a Flachbeile aus dem Dép. Côtes-d'Armor; b Flachbeil aus dem Hortfund von Ploudaniel; c Flachbeil aus dem Hortfund von Belz; d Beilklingen mit flachen Randleisten aus dem Tumulus von Trémel; e Beilklingen mit flachen Randleisten aus dem Tumulus von Crec'h Perros; f Absatzbeile aus dem Hortfund von Tréboul; g Beil mit langen Randleisten aus dem Hortfund von Tréboul.*

Early Bronze Age (EBA A 1–EBA A 2)

During the Early Bronze Age, most metal objects were found in burial mounds. Their association with other types of artefacts, notably daggers whose typology is much better defined, makes it easier to position them in time, although there is still much debate on the subject (Nicolas 2016). However, the flared and low-flanged axeheads appear to be globally similar (cf. Fig. 3c). The composition of this type of axe shows that it is mostly made of bronze with an average tin content of between 8 % and 14 % (average around 9 %). Gandois (2018) shows that during Early Bronze Age A1, only some of the objects were made of bronze, and the tin content seems to increase slowly over time. In Early Bronze Age A 2, all the objects were made of bronze, including the axes. A few low-flanged axeheads have been analysed in recent years at Rennes. Some axes have fairly high levels of Sb (1750, 1950, and 2350 ppm for three of them) or Ni (3500 and 7400 ppm for two other axes), while the levels for the majority of axes vary between 20 and 700 ppm for

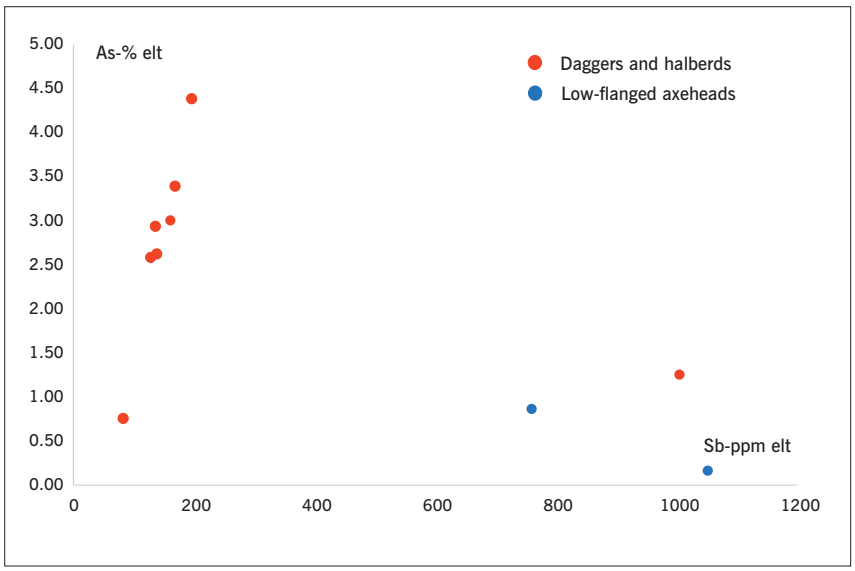


Fig. 4 Distribution of elemental chemical analyses in As-Sb diagram of Crec'h Perros artefacts.

Abb. 4 *Verteilung der Artefakte von Crec'h Perros im As-Sb-Diagramm.*

Ni and between 150 and 1100 ppm for Sb. These varying grades suggest that the copper may have come from more than one source. Only one axe is made of arsenic copper (1.2 % As), while the other bronze axes have low levels of As (on average 0.2 %).

The difference in alloy composition between axes and other objects (daggers, halberds) is significant. A number of the latter have higher As contents, ranging from 0 % to 4.5 %, with the majority having As contents of over 1.5 %, and fairly low Ni and Sb contents. It is difficult to interpret these data accurately, as some of the axes were found without a context, and for the others the dating of the burial mound is not necessarily known. There may also have been a chronological change in the composition of the alloy. But it could mean that, for some time, these different alloys coexisted, as in the case of the Crec'h Perros burial mound (Côtes-d'Armor; Blanchet 2005), where ten metal objects were found and all alloy compositions were represented (no published data). For this burial mound, however, the two axeheads and one halberd show a real difference in chemical signature, based on trace element content, compared with the other seven objects, which consistently have their own chemical signature (Fig. 4).

Unfortunately, no isotopic analysis has been carried out on Early Bronze Age axes, so it is impossible to discuss the origin of these metals. We can, however, discuss the presence of artefacts of different origins in the large north-western quarter of France. For example, »Rippenbarren« type ingots have been found as far north as the Bay of the Somme in northern France (Blanchet/Mille 2009), so why wouldn't this metal have travelled further west too? Likewise, *lunulae* similar to those found in Ireland have been found on the peninsula (Briard 1987), showing a definite connection between these two regions. This connection has also been highlighted by the presence of copper and, more rarely, bronze axes, known as Ploukilla type (cf. Fig. 3b), from Plouhinec and Ploudaniel (Finistère), which are similar in terms of typology to Killaha type axes from Ireland (Gandois et al. 2019). The copper in the Irish axes is thought to have come from the Ross Island mine, Ireland (Northover 2004; O'Brien 2023). Chemical analyses carried out at the C2RMF (Paris) and in Rennes on these Briton axes show a composition similar to that of Irish axes, suggesting that the copper also came from this mine. However, a local origin for some artefacts cannot be completely ruled out without future isotopic analyses of the objects and potential ore deposits.

First stage of Middle Bronze Age (A[Atlantic]-MBA 1/Br B)

From this period onwards, metal objects were found mainly in rare metal hoards among objects of other types, mainly weapons. Objects from this period show a very strong typological affinity with objects from the Acton Park horizon in the British Isles. The A-MBA 1 long-flanged axeheads are found in the Médoc (Lagarde-Cardona 2012) and Vendée department (Pautreau 1979), but also in Brittany, and palstaves come from Brittany, Normandy and the mid-western region (cf. Fig. 3d–f) (Nordez 2019).

The elemental chemical composition of the axes is identical to the other types of artefacts found in the deposits, with objects made of »classic« bronze and others of lead-rich bronze of up to 15.3 % Pb (Tab. 1). The tin content varied for all the objects with no influence from the lead content. As for trace elements, the composition is identical between classic bronze and lead bronze objects. There is a clear positive correlation between As and Ni (Fig. 5). Similarly, isotopic compositions were identical between the two groups. The presence of lead had no influence on the isotope ratio values.

In addition to the typological similarity with the artefacts from Great Britain, the comparison of elemental and isotopic chemical compositions shows also a real correspondence (cf. Fig. 5a–b). According to recent results, the copper in the »Acton Park« type objects comes from the Great Orme mine (Williams/Le Carlier de Veslud 2019). Indeed, it appears, judging from the similarity of chemical and isotopic compositions, that this metal was also used to produce the A-MBA 1 artefacts from the north-west of

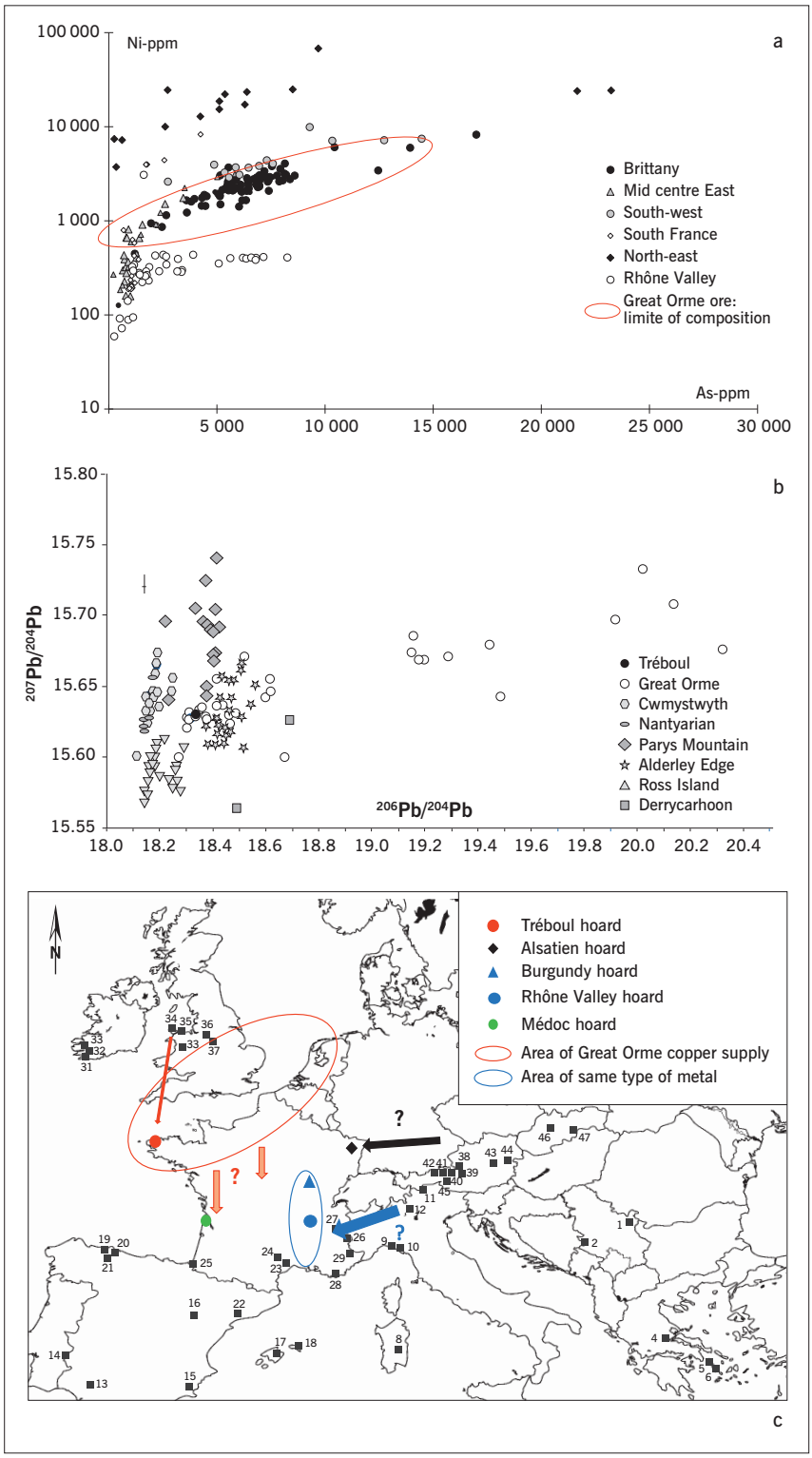


Fig. 5a–c a Comparison of Ni and As contents with contents from other hoards in France and with Great Orme ore contents; b Comparison of the isotopic composition of Tréboul artefacts with that of copper ores from the British Isles; c Location map of hoards: 1 Rudna Glava, Serbia; 2 Jarmovac, Serbia; 3 Ai Bunar, Bulgaria; 4 Othrys Mountains, Greece; 5 Kythnos, Greece; 6 Seriphos, Greece; 7 Troodos Mountains, Cyprus; 8 Funtana Raminosa, Italy; 9 Libiola, Italy; 10 Monte Loreto, Italy; 11 Trentino, Italy; 12 Campolungo, Italy; 13 Chinflon, Spain; 14 Mocissos, Portugal; 15 Sierra de Orihuela, Spain; 16 Loma de la Tejeria, Spain; 17 Mallorca, Spain; 18 Mitja Lluna, Spain; 19 El Aramo, Spain; 20 El Milagro, Spain; 21 La Profunda, Spain; 22 Montsant, Spain; 23 Cabrières, France; 24 Bouco Payrol, France; 25 Causiat, France; 26 Saint Véran, France; 27 Les Rousses, Frances; 28 Maraval, France; 29 Clue de Roua, France; 30 Ross Island, Ireland; 31 Mount Gabriel, Ireland; 32 Derrycarhoon, Ireland; 33 Cwmystwyth, Wales; 34 Parys Mountain, Wales; 35 Great Orme, Wales; 36 Alderley Edge, England; 37 Ecton, England; 38 Mitterberg, Austria; 39 St. Veit, Austria; 40 Saalfeldener Becken, Austria; 41 Kitzbühel Kelchalm, Austria; 42 Schwaz Brixlegg, Austria; 43 Eisenerz, Austria; 44 Prein, Austria; 45 Virgental, Liechtenstein; 46 Spania Dolina Piesky, Slovakia; 47 Spanie Pole, Slovakia.

Abb. 5a–c *a Ni- und As-Konzentrationen. Vergleich mit anderen Depotfunden aus Frankreich und mit dem Erzgehalt vom Great Orme, Wales; b Isotopenzusammensetzung. Vergleich der Artefakte aus Tréboul mit Kupfererzen von den Britischen Inseln; c Fundorte von Depots. 1 Rudna Glava, Serbien; 2 Jarmovac, Serbien; 3 Ai Bunar, Bulgarien; 4 Othrysgebirge, Griechenland; 5 Kythnos, Griechenland; 6 Serifos, Griechenland; 7 Troodos-Gebirge, Zypern; 8 Funtana Raminosa, Sardinien; 9 Libiola, Italien; 10 Monte Loreto, Italien; 11 Trentino, Italien; 12 Campolungo, Italien; 13 Chinflon, Spanien; 14 Mocissos, Portugal; 15 Sierra de Orihuela, Spanien; 16 Loma de la Tejeria, Spanien; 17 Mallorca, Spanien; 18 Mitja Lluna, Spanien; 19 Sierra del Aramo, Spanien; 20 El Milagro, Spanien; 21 La Profunda, Spanien; 22 Montsant, Spanien; 23 Cabrières, Frankreich; 24 Bouco-Payrol, Frankreich; 25 Causiat, Frankreich; 26 Saint-Véran, Frankreich; 27 Les Rousses, Frankreich; 28 Maraval, Frankreich; 29 Clue de Roua, Frankreich; 30 Ross Island, Irland; 31 Mount Gabriel, Irland; 32 Derrycarhoon, Irland; 33 Cwmystwyth, Wales; 34 Parys Mountain, Wales; 35 Great Orme, Wales; 36 Alderley Edge, England; 37 Ecton, England; 38 Mitterberg, Österreich; 39 St. Veit, Österreich; 40 Saalfeldener Becken, Österreich; 41 Kitzbühel-Kelchalm, Österreich; 42 Schwaz-Brixlegg, Österreich; 43 Eisenerz, Österreich; 44 Prein, Österreich; 45 Virgental, Liechtenstein; 46 Spania Dolina-Piesky, Slowakei; 47 Spanie Pole, Slowakei.*

France. The higher or lower amount of lead is linked to the presence of galena veinlets within the deposit intersecting the copper deposit and which may have been used in the composition of the charge in the smelting furnaces, hence the similarity of the isotopic compositions. It is therefore not a deliberate addition (Williams 2023).

Analysis of artefacts of the same chronology from other French regions (the Rhône Valley, southern France, Burgundy and Alsace) shows that the spread of this metal seems to have involved only the regions close to the Atlantic/North Sea coast (cf. Fig. 5c). Artefacts from Alsace to the north-east have a very different chemical composition. Similarly, artefacts from the south of France, from the Rhône Valley (cf. Fig. 3g; Delrieu et al. 2015) and from Burgundy (Forel 2009) have a chemical composition similar to each other but different from that of the north-west and Alsace. These deposits all contain axes that have hitherto been described as Neyruz type. However, these are copper axes containing very little tin (1 % Sn on average). It would seem that the typological attribution of these axes needs to be reviewed,

	Nb analyses	Pb (min)	Pb (max)	Pb average	Sn (min)	Sn (max)	Sn average	Ag (min)	Ag (max)	Ag average
First stage of Middle Bronze Age (BM A1/Br B)										
Classical bronze artefacts	62	0	1.5	0.4	2.4	18.1	10.3	40	948	346
Leaded bronze artefatcs	15	2	15.3	3.3	7.8	15.4	11.2	105	1030	377
Second stage of Middle Bronze Age (BM A2/Br C)										
Classical bronze axes	277	0.01	3.7	0.13	7.1	22.4	14.4	20	1210	173
First stage of Final Bronze (BF A1/Br D–Ha A1)										
Classical bronze artefacts	12	0.04	0.2	0.2	10.7	25.8	12.7	172	718	482
Second stage of the Late Bronze Age (BF A2/Ha A2–Ha B1)										
Copper ingots	3	0.2	0.4	0.3	0.05	0.2	0.06	257	1323	303
Poor trace element artefacts	12	0.09	22.5	2.1	7.4	14.7	11.8	279	1049	654
Leaded bronze ingots	26	2.5	48.5	18.1	3.4	18.4	11.5	157	5290	698
Ni rich artefacts	10	0.08	7.3	4.8	6.5	10.3	8.6	1574	5585	3238
As/Sb rich artefacts	25	0.4	28.2	8.2	5.4	15	9.8	290	4887	2913
Ag/As/Sb very rich artefacts	46	0.3	18.9	3.9	2.4	14.1	7.3	2220	15178	6013
End of the third stage of the Late Bronze Age (BF A3/Ha B2–B3)										
Atlantic type artefacts	86	0.07	37.8	3.26	2.7	19.4	9.9	135	2256	772
Copper ingots	28	0.01	0.9	0.14	0	0.7	0	33	8154	249
As only rich artefacts	5	0.09	9.2	1.1	0.01	14	3.1	76	1210	464
Sb only rich artefacts	7	0.5	22.8	3.4	8.2	13	10	866	1731	1174
Ag/Sb rich artefacts	4	3.1	22.82	4.5	7.5	7.9	7.6	2020	16215	14403
As/Sb rich artefacts	2	0.9	2.1		0.07	3.5		264	1176	
Ag/As/Sb rich artefacts	8	1.9	23.5	12.8	0.02	11.1	8.5	1737	22590	2866

since the axes attributed to the Neyruz type, particularly in Western Germany (Kienlin 2008), are made of bronze with a tin content either below 1 % or higher, between 3 % and 10 %. These variations seem to indicate a typological attribution that needs to be clarified.

Second stage of Middle Bronze Age (A-MBA 2/Br C)

Metal from the Middle Bronze Age 2 in north-western France is known from the very large number of hoards made up either solely of ornaments or solely of axes, or, much more rarely, of assemblages of various objects, essentially associating axes with other elements of ornaments or weaponry (Boulud-Gazo et al. 2017). The axes are palstaves of various types – Breton, Norman, and Central-Western and long-flanged type without a stop-ridge in Vendée and Aquitaine areas (Fig. 6a), which are scattered in the region of the same name (Fig. 7a). A total of 450 hoards have been identified in these regions, with a total of 3148 objects inventoried, including 2710 axes (Nordez 2019) with tin contents ranging from 9–15 % (average 12 %). This number is largely underestimated due to the fact that many hoards have gone unreported for decades. These types of axes can be recognised in much more distant regions, in central-eastern France for example, or even in the south, suggesting that objects were moved over long distances (Gabillot/Quentinet 2023). However, local copies are always possible.

Elemental analysis of the axes shows a very high compositional homogeneity for most of the Atlantic seaboard, from Normandy to the Vendée, with a classical bronze composition (cf. Tab. 1; Fig. 7b). Compositional homogeneity is also high relative to that of the axes from the Burgundy and Franche-Comté deposits as well as to the slightly later Malassis hoard in central France, which is made up of a greater variety of objects, including copper ingots (Briard et al. 1969).

This composition seems quite different from that of the previous period for north-western France, suggesting a radical change in the origin of the imported metal. However, some A-BMA 2 axes from the north-west show a chemical composition identical to objects from the previous A-MBA 1 period, and show a difference from axes from eastern and central France (cf. Fig. 7b). The compositions of the axes from Burgundy and the centre of France are really similar and do not come close at all to the composition of A-MBA 1. It is therefore possible to imagine that copper from the Great Orme mining area was still being used in part of north-western France in A-MBA 2, or that objects

As (min)	As (max)	As average	Ni (min)	Ni (max)	Ni average	Sb (min)	Sb (max)	Sb average
1200	16992	6100	448	8243	2214	0	1342	246
3812	7880	6965	1600	3813	2742	145	584	216
227	11473	2680	425	44245	5070	110	5000	1060
793	2150	1600	930	3330	2060	430	1036	813
2470	5814	2720	127	287	227	142	641	209
746	3201	1257	185	2831	615	360	2385	684
336	3900	1111	95	1200	334	189	7420	947
1711	10271	5460	2939	6413	4280	4154	12454	7780
373	8030	3491	220	2667	1215	1086	7675	5823
4079	20138	6383	671	2685	1739	7081	24674	9539
95	1500	1014	102	1296	685	314	6674	2963
22	41879	975	101	600	248	94	40740	789
4135	8000	5034	375	1206	413	1595	3748	1977
937	3310	2184	402	2772	1122	6705	35230	9210
124	1492	1300	100	6190	1810	3246	34753	6030
4220	7350		285	175		7111	44086	
2085	25090	5132	225	2464	810	9820	107025	13060

Tab. 1 Range in variation of the contents of alloying elements (Pb, Sn; values in elemental ppm) and trace elements (Ag, As, Ni, Sb; values in elemental ppm) for the different types of composition of artefacts from north-western France for the A-MBA 1, A-MBA 2, A-LBA 1, A-LBA 2, and recent A-LBA 3 periods.

Tab. 1 *Variationsbreite des Gehalts der Legierungselemente (Pb, Sn; Werte in ppm) und der Spurenelemente (Ag, As, Ni, Sb; Werte in ppm) für unterschiedliche Zusammensetzungen der Artefakte aus Nordwestfrankreich für die Zeiträume A-MBA 1, A-MBA 2, A-LBA 1 A-LBA 2 und A-LBA 3.*

from A-MBA 1 were being recycled in large numbers in this region. On the other hand, all the axes from hoards found in the northern part of France, in the west and east, show a very clear difference in composition from the artefacts from the south of France. It will therefore be possible to see whether palstaves of north-western typological attribution found in the south of France are local copies or whether they are objects imported from the north.

Isotopic analyses were carried out on axes from north-western France and central France (Fig. 8). Unfortunately, the axes from eastern France have not yet been analysed. Comparison of the isotopic compositions of the north-western axes with the signatures of major copper-mining areas in Europe suggests that the origin of the copper could be Italy. However, the signatures on the Malassis copper ingots seem to point to a Sardinian origin (central and south-west), on the one hand, and an Austrian origin, in the district of Mitterberg, on the other. The objects do not have the signature of the ingots but lie on a straight line connecting the points representing the ingots located in the two mentioned districts. The hypothesis of the use of copper from the Great Orme mine is not confirmed by these analyses, as the orientation of the alignment of the points representing the objects does not point towards the Great Orme isotopic domain.

First stage of Late Bronze (A-LBA 1/Br D–Ha A1)

In the first period of the Late Bronze Age, the type of palstave changed, as did the type of hoard, in which the artefacts are varied and partially fragmented. The number of hoards as well as the number of artefacts per hoard is also much lower. Palstaves, known as »Rosnoën« axes, become more massive and have a right-angled stop-ridge (cf. Fig. 6b). The chemical (cf. Tab. 1; Fig. 7b) and isotopic (cf. Fig. 8) compositions of the axes are identical to those of the other objects in the hoard. These compositions are also identical to those of the previous period. While the typology of the axes has changed, as have the methods of deposition, the copper supply circuits seem to remain the same as before. However, given the limited number of analyses carried out during this period, these results should not be considered definitive.

Second stage of the Late Bronze Age (A-LBA 2/Ha A2–Ha B1)

In Late Bronze Age 2, there are more hoards, but far fewer than in MBA 2. The artefacts are highly fragmented. Axes are represented by massive palstaves, also known as »Rosnoën« type axes because they are fairly identical to the pre-

Fig. 6a–d a1 A-MBA 2 Brittany type palstave (to the left, Saint-Thois); a2 A-MBA 2 Norman type palstave (in the centre, Mouilleron-en-Pareds); a3 A-MBA 2 Vendean type strong edge axes (on the right, Mouilleron-en-Pareds); b A-LBA 1 Rosnoën type palstave, Rosnoën; c1 A-LBA 2 Rosnoën type palstave, Saint-Brieuc-des-Ifs; c2 A-LBA 2 winged axe, Soullans; c3 A-LBA 2 socketed axe, Soullans; d recent A-LBA 3 Plainseau type socketed axes, Gouesnac'h; d1 recent A-LBA 3 Wales type socketed axe, Gouesnac'h; d2 recent A-LBA 3 winged axe, Gouesnac'h; d3 recent A-LBA 3 winged axe, Gouesnac'h; d4 recent A-LBA 3 Nuragic type axe ingot, Mérézel; d5 recent A-LBA 3 palstave, La Rouillasse.

Abb. 6a–d *a1 Atlantische Mittelbronzezeit 2 (A-MBA 2), Absatzbeil vom bretonischen Typ, Saint-Thois; a2 A-MBA 2, Absatzbeil vom normannischen Typ, Mouilleron-en-Pareds; a3 Randleistenbeil vom Typ Vendée, Mouilleron-en-Pareds (A-MBA 2); b Atlantische Spätbronzezeit 1 (A-LBA 1), Absatzbeil vom Typ Rosnoën, Rosnoën; c1 A-LBA 2, Absatzbeil vom Typ Rosnoën, Saint-Brieuc-des-Ifs; c2 A-LBA 2, Lappenbeil, Soullans; c3 A-LBA 2, Soullans; d A-LBA 3, Tüllenbeile vom Typ Plainseau, Gouesnac'h; d1 A-LBA 3, Tüllenbeil vom walisischen Typ, Gouesnac'h; d2 A-LBA 3, Lappenbeil, Gouesnac'h; d3 A-LBA 3 Lappenbeil, Gouesnac'h; d4 A-LBA 3, Beilbarren vom Typ Nuragic, Mérézel; d5 A-LBA 3, Absatzbeil, La Rouillasse.*

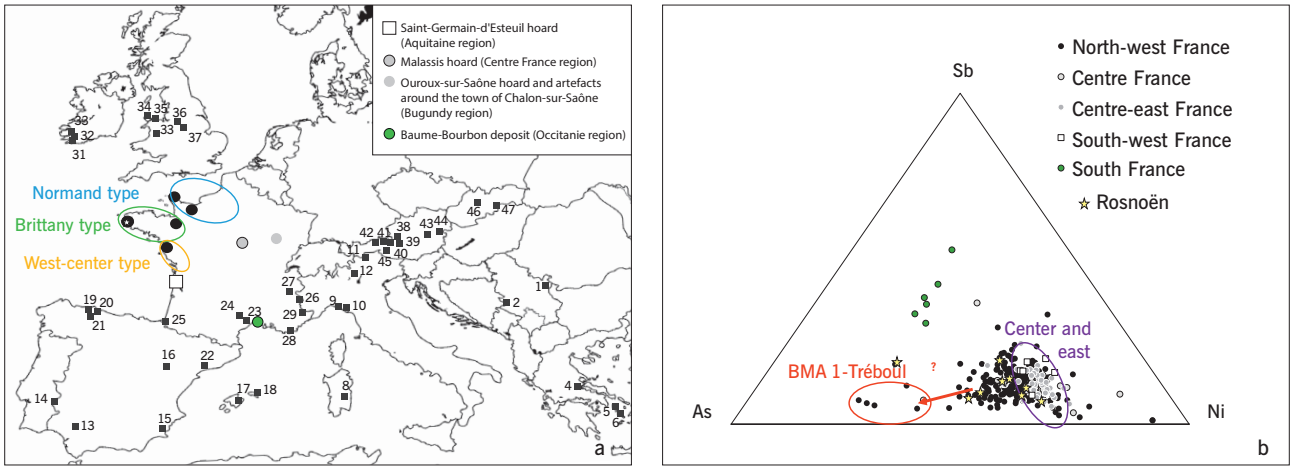
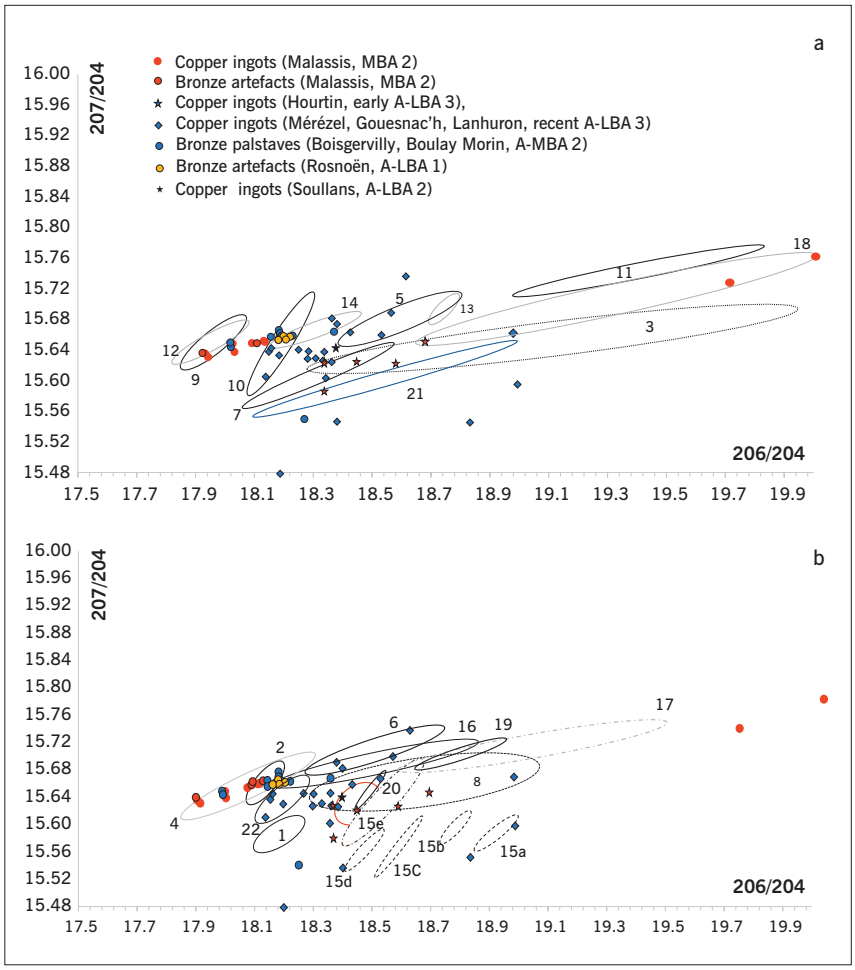


Fig. 7a–b a Distribution areas of A-MBA 2 palstaves (see name of copper mines in Fig. 5); b distribution of A-MBA 2 axe elemental analyses in As-Ni-Sb diagram, and comparison with MBA 2 axes from other French regions, and with A-MBA 1 artefacts.

Abb. 7a–b *a Verbreitungsgebiete von A-MBA 2 Absatzbeilen (siehe Abb. 5 für die Namen der Kupferminen); b Verteilung von A-MBA 2-Beilen im As-Ni-Sb-Diagramm und Vergleich mit MBA 2-Beilen anderer französischer Regionen und mit A-MBA 1-Artefakten.*

Fig. 8a–b Comparison of lead isotopic composition of artefacts with some copper ore deposits from Europe: 1 Ross Island, Ireland; 2 Copa Hill, Wales; 3 Great Orme, Wales; 4 Central and south-western Sardinia, Italy; 5 Northern and north-western Sardinia, Italy; 6 Cabrières, France; 7 Queyras, France (including Saint Véran); 8 Slovakia; 9 Jaén, Spain; 10 Huelva, Spain; 11 Asturies, Spain; 12 Vlasugana, Italy; 13 Southern Toscana, Italy; 14 Southern Alps, Italy; 15a Kalavassos, Cyprus; 15b Larnaca 1, Cyprus; 15c Larnaca 2, Cyprus, 15d Solea, Cyprus; 15e Limassol, Cyprus; 16 North Tyrol, Austria; 17 Tyrol, Austria; 18 Mitterberg, Austria; 19 Baia Mare, Romania; 20 Apuseni, Romania.

Abb. 8a–b *Vergleich der Bleiisotopenzusammensetzung von Artefakten, deren Material aus europäischen Kupfererzvorkommen stammt. 1 Ross Island, Irland; 2 Copa Hill, Wales; 3 Great Orme, Wales; 4 Zentral- und Südwestsardinien; 5 Nord- und Nordwestsardinien; 6 Cabrières, Frankreich; 7 Queyras, Frankreich (einschl. Saint-Véran); 8 Slowakei; 9 Jaén, Spanien; 10 Huelva, Spanien; 11 Asturies, Spanien; 12 Vlasugana, Italien; 13 südliche Toskana, Italien; 14 südliche Alpen (Südtirol, Trentino und Venetien), Italien; 15a Kalavassos, Zypern; 15b Larnaca 1, Zypern; 15c Larnaca 2, Zypern; 15d Solea, Zypern; 15e Limassol, Zypern; 16 Nordtirol, Österreich; 17 Tirol, Österreich; 18 Mitterberg, Österreich; 19 Baia Mare, Rumänien; 20 Apuseni, Rumänien.*



vious period (cf. Fig. 6c). It was from this period onwards that the first subterminal-winged axeheads and socketed axes were also found in western France; however, these are less common than palstaves.

Axes have the same chemical composition as other types of artefacts (cf. Tab. 1). What is special about this period is the nature of the alloy, which contains lead (from 0.43–28.22 %, with an average of 3.23 %) in addition to copper and tin. A comparison of the composition of these palstaves with that of axes from the previous period, all defined as »Rosnoën« type axes, shows a clear difference in elemental and isotopic composition between these two populations.

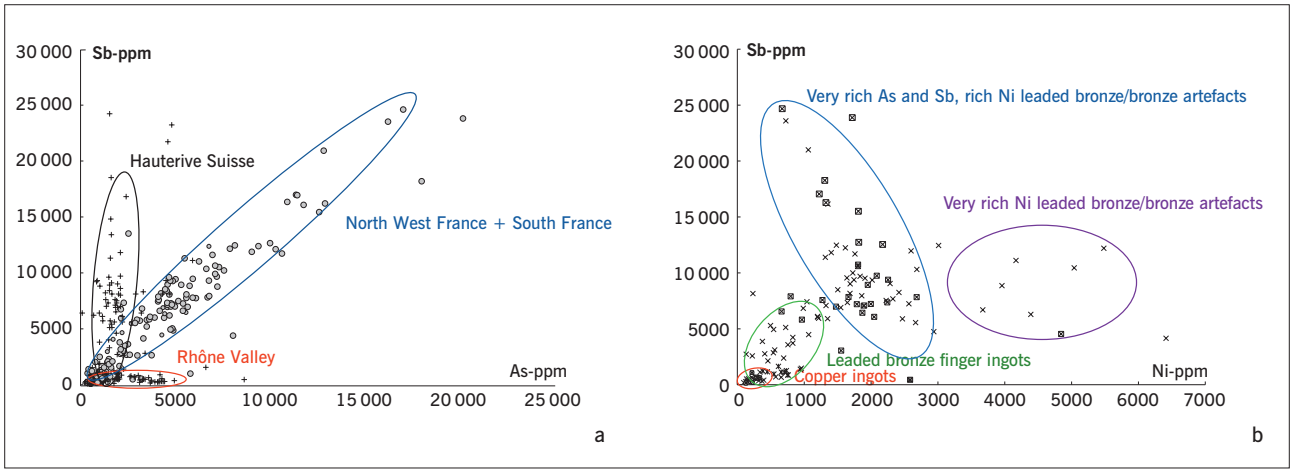


Fig. 9–b a Comparison of Sb and As contents of artefacts from north-western France with that of the Rhône Valley artefacts (unpublished data) and Hauterive from Switzerland; b distribution of elemental chemical analyses in Sb-Ni diagram of different types of composition for A-LBA 2 artefacts.

Abb. 9a–b *a Vergleich Sb- und As-Konzentrationen in Artefakten aus Nordwestfrankreich mit denen in Artefakten aus dem Rhône-Tal (unpublizierte Daten) und aus Hauterive, Schweiz; b Verteilung von Artefakten der A-LBA 2 unterschiedlicher Zusammensetzung im Sb-Ni-Diagramm.*

Date	Site	Type of axe	Reference	Cu	Pb	Sn	Ag	As	Bi	Co	Fe	Ni	Sb	Zn
Bell Beaker	Île Lemaire	Flat axehead	2801 coll. B	93.98	0	0	0	33816	1219	6	51	2921	1555	266
			2800 coll. B	93.11	0	0	0	46726	755	679	464	2198	2221	441
			2802	92.04	0,00	0	0	58177	547	166	0	3591	608	379
	Riec-sur-Bélon			89.16	0	0	354	26747	4652	191	3385	41122	2904	471
	Maxent			94.24	0	0	0	40081	444	6	0	523	529	438
EBA	Crec'h Perros	Low-flanged axehead	185-2	92.01	0.02	7.30	1119	1600	595	9	608	1048	1052	570
			185-1	90.38	0.02	8.34	32	8600	595	11	1316	601	760	559
A-MBA 1	Tréboul		49 5 16/21	87.04	0.80	11.04	338	6442	538	207	433	2399	279	458
			49 5 16/34	75.78	15.31	7.85	377	6888	477	16	35	2278	204	328
			49 5 16/7	85.54	2.07	11.14	360	7391	547	200	666	2709	232	408
			49 5 16/12	82.21	0.31	16.12	293	6834	517	206	2068	2890	217	501
A-MBA 2	Boisgervilly	Palstave	n°1	79.67	0.07	16.18	185	4428	509	287	860	33408	725	329
			n°2	82.94	0.19	15.79	289	3758	552	305	586	3823	1075	354
			n°3	83.99	0.22	14.72	690	2523	528	217	2182	3663	483	377
			n°4	86.24	0.01	12.84	125	1948	510	367	1812	3552	404	271
			n°5	82.96	0.15	15.77	220	3852	548	357	362	4622	808	336
A-LBA 1	Rosnoën	Palstave	49.1.8	84.87	0.19	13.03	459	2103	686	241	11038	2953	1019	527
			49.1.9	85.27	0.22	13.69	705	1546	828	397	1322	1799	864	706
A-LBA 2	St. Brieuc des Ifs	Palstave	St-Brieuc 10	75.15	12.35	8.41	4240	4763	300	302	111	2242	7368	526
			St-Brieuc 3	67.93	18.90	7.97	4551	5151	294	178	107	1273	7576	476
			St-Brieuc 7	86.11	3.41	7.10	5986	6761	356	368	2140	2255	9393	676
			St-Brieuc 23	88.44	1.51	7.67	5408	5569	358	210	83	1662	7845	694
Recent A-LBA 3	Mérézel	Socketed axe	MZL 176	76.50	9.18	14.01	1209	8002	509	138	37	1206	1977	176
		Winged axehead	MZL 175	86.29	2.54	10.78	647	1114	277	6	170	520	3410	286
			MZL 425	86.39	3.35	9.59	1103	2741	288	44	99	1273	6705	206
		Sardinia axe	MZL 114	95.50	0.09	3.11	76	5034	285	0	45	375	1595	671
		Socketed axe	MZL 421	87.20	1.23	11.31	135	95	261	0	176	121	314	265

Tab. 2 Elemental composition of some axes from north-western France from EBA to recent LBA.

Tab. 2 *Elementzusammensetzung einiger Beile aus Nordwestfrankreich von EBA bis zur jüngeren LBA.*

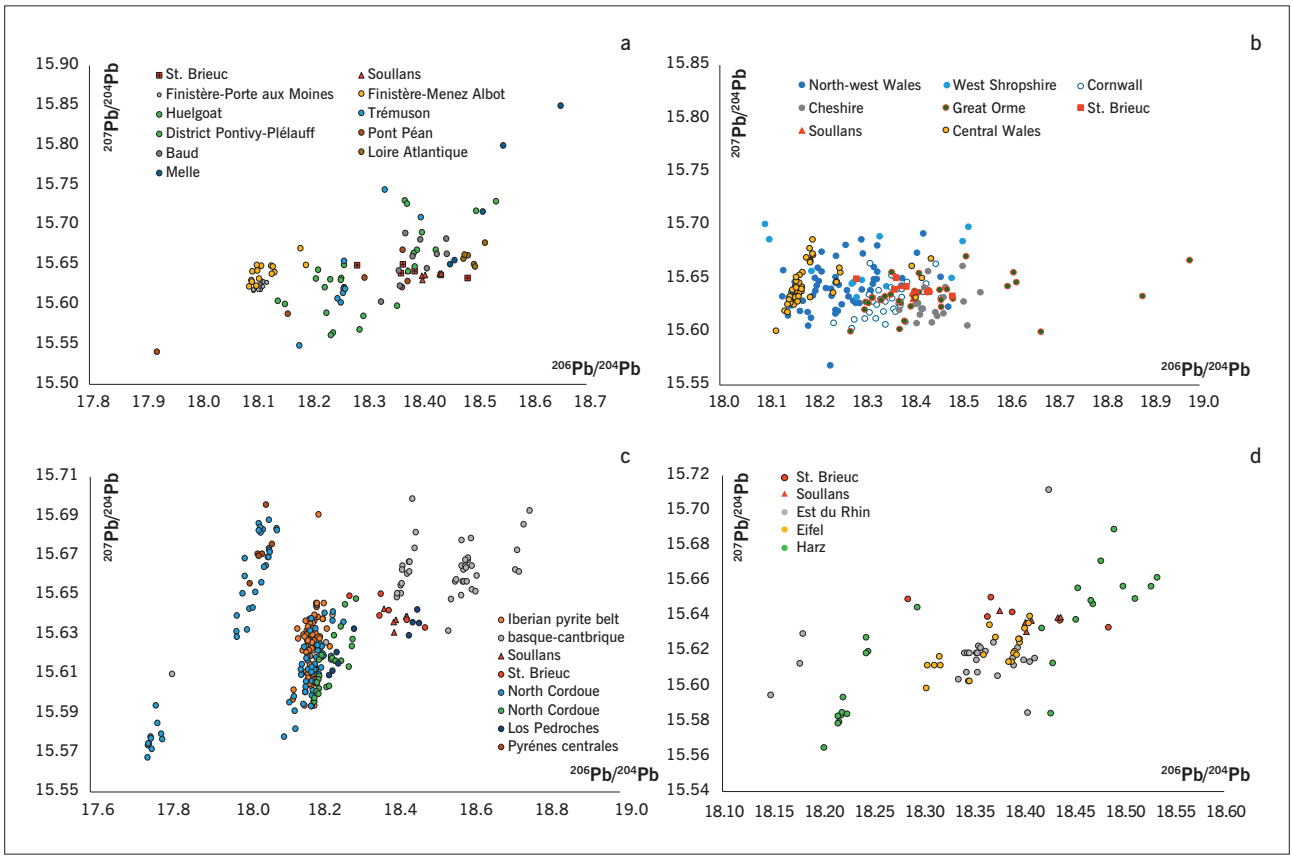


Fig. 10a–d Comparison of lead isotopic composition of A-LBA 2 artefacts with some lead ore deposits from Western Europe: Great Britain, Germany, Brittany, Spain.

Abb. 10a–d *Vergleich der Bleiisotopenzusammensetzung von Artefakten der A-LBA 2 mit der einiger Bleierzvorkommen in Westeuropa: Großbritannien, Deutschland, die Bretagne, Spanien.*

The A-LBA 2 axes contain lead, while the A-LBA 1 axes do not. Similarly, the levels of the four main trace elements do not correspond at all. The isotope ratios are also different. This leads us to believe that the origin of the metal changes completely between the A-LBA 1 and A-LBA 2, in north-western France, whereas the typology of certain objects remains more or less identical.

Another case study highlights the late use of axes produced in earlier periods. For example, a Breton palstave from the A-MBA 2 period, found in an A-LBA 2 hoard in Vendée (Boulud-Gazo et al. 2022), has the chemical and isotopic composition of objects from this earlier period.

More generally in France, A-LBA 2 axes and artefacts from the north-west show a similarity in elemental composition to artefacts from the south of France, but are completely different from those from the Rhône Valley (unpublished data) and Switzerland (Fig. 9a; Rychner/Kläntschi 1993).

Nevertheless, objects from the Atlantic seaboard seem to be made from copper of several different origins (cf. Fig. 9b). The copper may come from: 1) copper ingots; 2) bronze ingots containing high levels of lead (cf. Tab. 1) – these two types of ingots have been observed in the deposits and have fairly low levels of As, Ni, and Sb; 3) some objects show a very high nickel content, implying another type of source; 4) other objects are also very rich in Sb and As, implying yet another source. These last two compositions do not correspond to the compositions of the A-MBA 2 axes, which are much less rich in As, Ni, and Sb. The mixture of sources can also be seen in the isotopic analyses, with the points representing the analyses aligned on a mixing line (Fig. 10).

The very high lead content in the bar ingots suggests that lead was added to the alloy. Comparing the isotopic compositions of A-LBA 2 objects, including axes, with copper deposits is not really meaningful. Comparing these isotopic compositions with European lead deposits does not provide any information either. In fact, several artefacts correspond to these compositions: the Armorican Massif (Marcoux 1986), the British Isles (Rohl 1996), and Western Germany (Bode 2008).

The isotopic analysis of one of the two copper ingots from the Soullans hoards seems to indicate an origin from Slovakia or Great Orme (cf. Fig. 8). However, a comparison of the elemental compositions of the A-LBA 2 objects with those of the A-MBA 1 objects, the copper of which almost certainly came from Great Orme, shows that these two groups of objects do not have the same elemental composition at all: the A-MBA 1 objects are much less rich in Sb. So Great Orme copper couldn't be the source. The same situation was observed for copper ingots from the Hourtin deposit (Médoc), dated to the following period (Couderc et al. 2021).

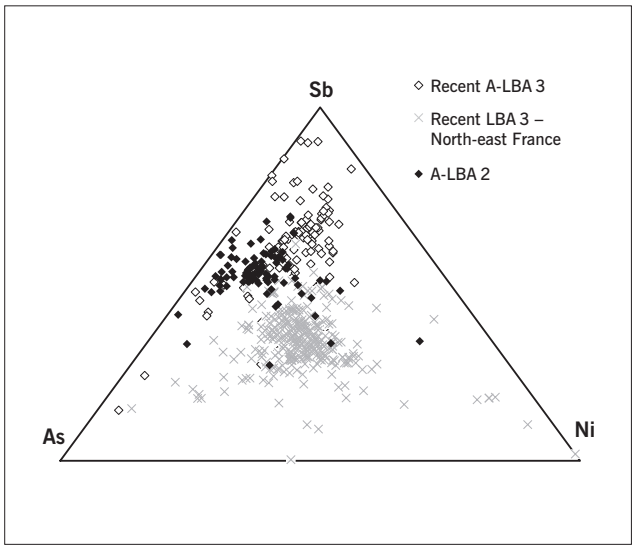


Fig. 11 Comparison of elemental composition of A-LBA 2 artefacts from north-western France, recent A-LBA 3 artefacts from north-western France, and LBA 3 artefacts from north-eastern France in the ternary diagram As-Ni-Sb.

Abb. 11 *Vergleich der Elementzusammensetzung von Artefakten der A-LBA 2 aus Nordwestfrankreich, der A-LBA 3 aus Nordwestfrankreich und der LBA 3 aus Nordostfrankreich im As-Ni-Sb-Dreiecksdiagramm.*

End of the third stage of the Late Bronze Age (recent A-LBA 3/Ha B2–B3)

In the recent Late Bronze Age 3, there are an extremely large number of metal hoards, with a wide variety of objects, including numerous fragments of copper ingots (Milcent 2012; Bordas 2023). Hoards contain many winged and socketed axes of local typology, some rare massive palstaves named once again the »Rosnoën« type, and some rare palstaves identified as A-MBA 2 relics. Some rare exotic axes such as the Wales type and Sardinian type axes can also be observed (cf. Fig. 6d). The Sardinian axe should be considered a bronze ingot because it is raw from the foundry. It is worth noting that at this period, metal did not only travel in the form of ingots, but manufactured objects were also part of the trade. As in the previous period, objects are largely fragmented, axes are no more numerous in hoards than other types of objects, and the majority of the axes seem to be used.

Elementary chemical analyses show a wide range of compositions suggesting various sources of copper. It should be noted that the majority of objects, including axes, have lead in the alloy (cf. Tab.1), as do the Sardinian axes. A comparison of the elemental compositions of objects including axes of the recent Late Bronze Age 3 with those of Late Bronze Age 2 shows similarities for a number of objects, suggesting continuity in the supply of copper from the same sources (Fig. 11). Comparison with objects from the east of France shows that the copper supplying the Atlantic domain is significantly different from that supplying the continental domain (cf. Fig. 11). Isotopic analysis values are highly variable, implying multiple supplies throughout Europe, perhaps Slovakia, Wales, Spain, the south of France, the Occidental Alps (except Austria), Cyprus and Sardinia (cf. Fig. 8). These hypotheses must be verified by elementary analyses.

Conclusion

In conclusion, it is not easy to define the origin of copper in bronze artefacts in a region where there is a lack of copper. It cannot be excluded that some copper objects may be related to regional copper ores for the Chalcolithic period, or even for the Early Bronze Age. But it seems fairly certain that copper was imported from various European mining districts from the Middle Bronze Age onwards. Until the Middle Bronze Age 1, copper seems to have come from Atlantic areas. But from the Middle Bronze Age 2 onwards, the supply of metal became much more important, with various sources, some of them probably very distant. Although this region is located at the end of the continent, it seems that it has always been part of a network for the exchange of goods. Perhaps the numerous tin deposits in Brittany encouraged these exchanges. In the earliest periods, from the Chalcolithic to the Early Bronze Age, the axes appear to have had an important social value. Like other metal objects, they seem to have been traded over long distances. From A-MBA 1 onwards, axes do not seem to be objects of greater value than others, and are treated in the same way in hoards, except for the Middle Bronze Age 2, where the specificity of axe hoards is remarkable and continues to raise questions.

The program developed in north-western France is far from complete. A great amount of work remains to be done on objects from the Chalcolithic period and the Early Bronze Age. Numerous chemical and isotopic analyses are still needed to try and identify the many sources of copper used during the Late Bronze Age. A greater number of analyses taken into account in this way can highlight chemical signatures that differ to a greater or lesser extent depending on the period under consideration. This makes it possible to see possible continuities in the supply of metal or real ruptures.

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Beyond the surface: Investigating the internal and external properties of silver-coated axes from eastern Bohemia

Eva Schimerová, Markéta Havlíková, Šárka Msallamová, and Christian-Heinrich Wunderlich

Zusammenfassung

Jenseits der Oberfläche: Die Untersuchung der internen und externen Eigenschaften von versilberten Beilen aus Ostböhmen

In einer multiperspektivischen Studie wurden sämtliche erhaltene Aunjetitzer Metallbeile aus Ostböhmen untersucht, darunter 111 Beile und 2 beilförmige Hämmer. Mit seinen 57 Objekten stellt der Hort von Kukleny, Okr. Hradec Králové, nach wie vor das umfangreichste Beilinventar dieser Periode in Böhmen dar. Sein Fundort in Ostböhmen wird oft als Peripherie der böhmischen Aunjetitz-Besiedlung betrachtet. Dies und die einzigartige Oberflächenbehandlung der Beile mit Silber machte es nötig, auch alle anderen Artefakte der Region zu untersuchen. Es handelt sich dabei meist um Stücke aus Hortfunden oder um Einzelfunde, seltener stammen sie aus Gräbern oder gar stratifizierten Siedlungsbefunden.

Unterschiedliche Methoden wurden mit dem Ziel angewandt, Fragen zu Herstellung, Verwendung und zum symbolischen Wert solcher Artefakte zu beantworten. Untersucht wurden Materialwahl, Gusstechnik, Herstellungs- und Gebrauchsspuren sowie der Silberüberzug. Vor allem in den Horten war eine Vorliebe für Bronze- anstatt Kupferbeile sichtbar. Die Untersuchung der inneren Strukturen lässt vermuten, dass einige der Beile in geschlossenen, aufrechtstehenden Formen mit der Schnittkante nach unten gegossen wurden, worauf Gussfehler am Beilnacken hindeuten. Wo sich Gebrauchsspuren fanden, ließ sich nachweisen, dass die Beile hauptsächlich für Holzarbeiten verwendet wurden. Dieser Befund steht im direkten Widerspruch mit dem Silberüberzug auf der Mehrzahl der untersuchten Stücke. Versuche ergaben jedoch eine spezielle Beschichtungsmethode, mit der man vergleichsweise einfach mit einer geringen Menge Silberchlorid (sog. Hornsilber) eine silbrig glänzende Oberfläche erhält. Die Oberfläche lässt sich damit leicht reparieren, sodass die praktische Verwendung der Beile nicht ausgeschlossen war.

Schlagwörter Frühbronzezeit, Aunjetitzer Kultur, Hortfunde, Äxte, Silberbeschichtung

Summary

A multi-perspective study was conducted on the entire preserved assemblage of Únětice metal axes from eastern Bohemia, including 111 axes and 2 axe-shaped hammers. With 57 specimens, the hoard of Kukleny, Hradec Králové district, still remains the largest assemblage of axes from this period in Bohemia. Its location in eastern Bohemia, often seen as a periphery of the Bohemian Únětice settlement, and the unique surface treatment of the axes with silver, made it necessary to investigate all other artefacts of the region, most of them coming from hoards and single finds, more rarely from graves and even stratified settlement contexts.

Different methods were applied and aimed to answer questions about the manufacture, use, and symbolic value of such artefacts. Their manufacture process was examined in terms of the choice of material, casting process, traces of manufacture and use, and silver coating. A preference for bronze over copper axes was observed, mainly in hoards. From the study of internal structure, we can propose that some of these axes were cast in closed moulds standing upright with the edge pointing down, which is indicated by casting defects present in the butt parts. Where traces of usage could be determined, it could be confirmed that axes were used mainly for woodworking. These findings seem to be in direct opposition to coating with silver, which was present on the majority of studied specimens. However, a specific coating method was tested, which provided a silvery shining surface using a fairly simple process and a minimal amount of silver chloride, or so-called horn silver. This way, the layer could have been easily repaired and did not have to exclude the practical use of axes.

Keywords Early Bronze Age, Únětice Culture, Hoards, Axes, Silver coating

Introduction

The Únětice Culture in eastern Bohemia is relatively little known. While during its early phases, eastern Bohemia shows little evidence of settlement and the only source of information are graves, during the Classical phase (starting around 2000 BC) the settlements and cemeteries begin to appear. Outstanding graves have recently been published from the cemetery of Mikulovice, Pardubice district (Ernée et al. 2020).

This view of the eastern Bohemian Únětice Culture as a somehow peripheral region, compared to central or northwestern Bohemia and Central Germany, has recently been questioned thanks to the discovery and investigation of two hoards. The most exceptional find of recent years was the deposit of metal axes from Kukleny, located in the vicin-

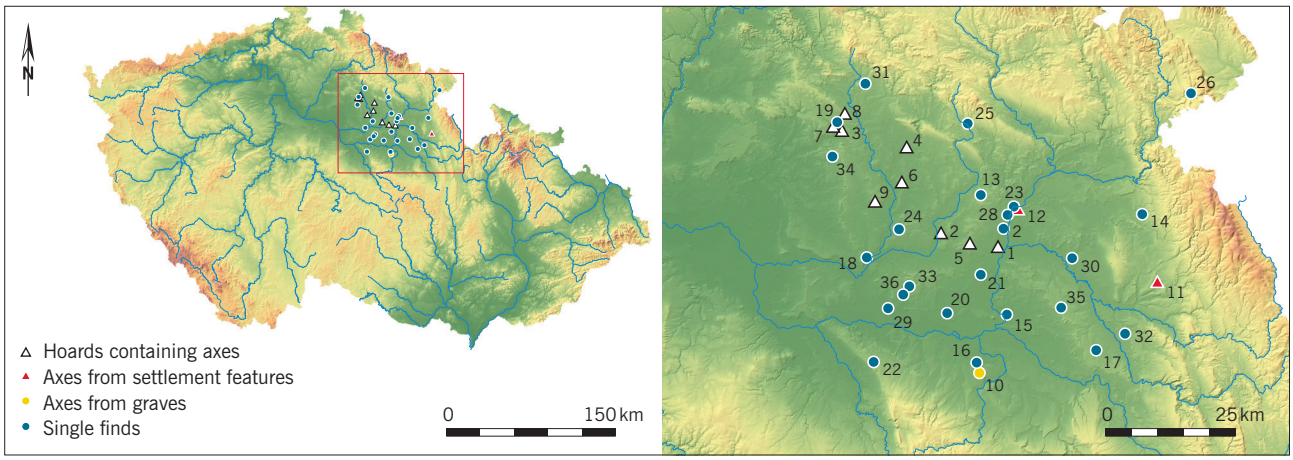

Fig. 1 Distribution of axes in eastern Bohemia according to their context. Hoards: 1 Kukleny; 2 Kunčice; 3 Jičíněves; 4 Obora; 5 Těchlovice; 6 Loučná Hora; 7 Dolany; 8 Staré Místo; 9 Starý Bydžov. Graves: 10 Mikulovice. Settlement: 11 Domašín; 12 Lochenice. Single finds: 13 Čistěves; 14 Dobruška; 15 Dražkov; 16 Dražkovice; 17 Horní Jelení; 18 Chlumec nad Cidlinou; 19 Kostelec; 20 Lázně Bohdaneč; 21 Libišany; 22 Litošice; 23 Lochenice; 24 Měník; 25 Miletín; 26 Nízká Srbská; 27 Plotiště nad Labem; 28 Předměřice nad Labem; 29 Strašov; 30 Třebechovice; 31 Valdice; 32 Velká Čermná; 33 Voleč; 34 Vršce; 35 Vysoké Chvojno; 36 Žáravice.

Abb. 1 *Verbreitung der Beile in Ostböhmen nach Fundzusammenhang. Horte: 1 Kukleny; 2 Kunčice; 3 Jičíněves; 4 Obora; 5 Těchlovice; 6 Loučná Hora; 7 Dolany; 8 Staré; 9 Starý Bydžov. Gräber: 10 Mikulovice. Siedlungen: 11 Domašín; 12 Lochenice. Einzelfunde: 13 Čistěves; 14 Dobruška; 15 Dražkov; 16 Dražkovice; 17 Horní Jelení; 18 Chlumec nad Cidlinou; 19 Kostelec; 20 Lázně Bohdaneč; 21 Libišany; 22 Litošice; 23 Lochenice; 24 Měník; 25 Miletín; 26 Nízká Srbská; 27 Plotiště nad Labem; 28 Předměřice nad Labem; 29 Strašov; 30 Třebechovice; 31 Valdice; 32 Velká Čermná; 33 Voleč; 34 Vršce; 35 Vysoké Chvojno; 36 Žáravice.*

ity of Hradec Králové. With 57 axes originally stored in a ceramic vessel, it is the largest hoard of axes found so far in the Czech Republic. Such assemblages would be expected in north-western Bohemia[1], which is close to Central Germany, where the largest axe hoards have been found (Brunn 1959). Another eastern Bohemian deposit of eight axes has recently been found in Kunčice, Hradec Králové district. Detailed observation of the surfaces of some axes of both hoards allowed archaeologists to identify traces of silver (Schimerová et al. 2023). This is particularly interesting in the context of Central Europe because practically no silver objects are known so far.

In the present study, the Early Bronze Age axes of eastern Bohemia are submitted to an interdisciplinary approach combining elemental composition, metalwork wear, and internal structure analyses. Particular attention was devoted to the possibilities of silver-coating technology and its experimental replication.

Materials and their contexts

In total, 113 axes or their fragments are preserved from Únětice contexts in eastern Bohemia (Fig. 1), from these

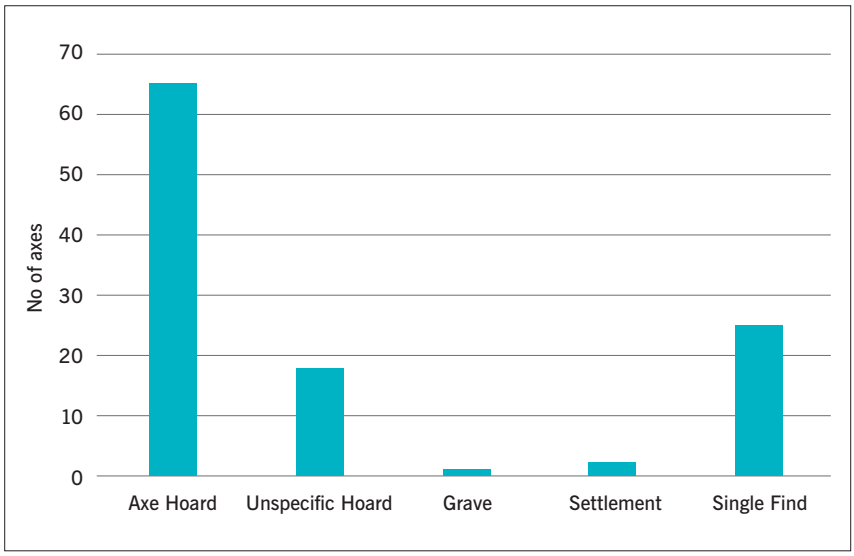

Fig. 2 Number of studied axes found in different archaeological contexts in eastern Bohemia.

Abb. 2 *Anzahl der untersuchten Beile aus Ostböhmen nach archäologischem Kontext.*

1 E.g. Soběnice, Litoměřice district, 40 axes, Soběchleby, Louny district, over 30 axes; see Moucha 2005.

only 109 were available for analysis. Another two axe-shaped artefacts are usually described as hammers. A total number of 111 from the total number of 113 artefacts are discussed in the present study. All axes can be grouped according to four different find circumstances (Fig. 2); in this case hammers form a separate category:

- Axes from hoards
- Axes from graves
- Axes from settlement features
- Single finds

Axes from hoards

This group of finds is the most numerous and comprises 83 axes. The hoards can be divided into two categories. In the first category, axes are the only component. It includes the hoards of Kukleny, with 57 axes (Fig. 3), and Kunčice (Fig. 4) with eight (for details, see Schimerová et al. 2023). The second category of hoards commonly only contains one or two axes as part of a more varied assemblage of artefacts, including either pieces of jewellery, clothing accessories, or ingots. In a third group of hoards, axes are absent[2].

The mixed hoard with the largest amount of axes came from Jičíněves, Jičín district. It was found in the 19th century in two separate assemblages. Although it cannot be excluded that they all came from one hoard, the information is very incomplete and parts of the original assemblage were lost. The total number of axes of both assemblages could have been c. 25, including fragments, which seem to have been found together with other artefacts. Today, only eight axes, one hammer, and eleven ring ingots are preserved in four different museums (Moucha 2005, 114–115 Tab. 71–73).

Another hoard found in 1904 came from Obora, Jičín district. Similar to all early finds, a large part of the assemblage is lost. The total number of axes was nine, although only three of them are still extant today. The hoard was stored in a vessel, and along with the axes it also contained a metal chain and bracelets and their fragments (Moucha 2005, 133 Tab. 158).

The hoard from Těchlovice, Hradec Králové district, contained two axes, but no written report describing the find's circumstances exists (Fig. 5). The only information was provided by T. Vachta, who described the hoard context after communication with the local museum. According to this information, there were two axes deposited lengthwise next to each other; between the two axes was a pin, and eight ingots were placed on top (Vachta 2016, 84). In the published reconstruction, the ingots are in the form of ribs, which are specific for southern Bohemia, but so far remain unknown in eastern Bohemia (Chvojka et al. 2017; Moucha 2005). A misunderstaning might have been created by the fact that these ingots were most probably reshaped from the typical ring ingot by shortening them and probably filing them into sharp ends. Due to significant corrosion damage this modification is hard to prove.

Another assemblage with two axes which is described as a hoard comes from Loučná Hora, Hradec Králové district, although only these two artefacts were retrieved. Both were very different in size, but their presence in the same place is definitely not a coincidence (Fig. 6).

The remaining hoards contained just one axe each, in addition to other objects. The most notable example is the yet unpublished hoard from Dolany, Jičín district. It was found in the summer of 2020, but delivered to the museum much later. According to the finder, the assemblage contained one broken axe, four bracelets, one broken Únětice pin, a wire spiral, and a cast decorated comb. Apart from these complete artefacts, the finder also brought four fragments of thick wire – possibly from a pin and a piece of metal sheet, which could have belonged to the pin. The only available information about the find circumstances is a verbal description of the finder, who claimed that the hoard was placed in a typical large Únětice cup of the classical phase. Inside the cup was the spiral, and on top if it were the four bracelets with the axe placed in the middle. The most unusual find was a metal comb placed on the bottom of the ceramic vessel. The position of the pin and other metal fragments remains unknown (Fig. 7). Even though the compostion of the hoard is very unusual, according to the available description it can be excluded that the artefacts came from a disturbed grave.

The other two hoards contained only one axe. The first comes from Staré Místo, Jičín district, where fragments of an axe and a ring ingot were found (Moucha 2005, 156 Tab. 215); the second is the famous hoard from Starý Bydžov, Hradec Králové district, which, in addition to the axe, contained one decorated round metal disc, a decorated sheet ornament, three decorated pins, eight disc-shaped earrings, two spirals made of single wire, 18 rings made of double wire, and a bracelet – all stored in a ceramic vessel (Moucha 2005, 157–158 Tab. 96–97).

Although the find circumstances are unclear in all cases, most of the hoards appeared inside ceramic vessels. In the case of Kukleny, part of a storage vessel with copper corrosion adherences on the inner side was excavated in the shallow feature where the hoard was stored before it was disturbed by ploughing. The hoard from Dolany was stored in a classical Únětice cup. And the hoards from Starý Bydžov and Obora were also stored in a vessel, although its shape remains unknown.

Axes from graves

In eastern Bohemia, there is only one axe from a funerary context. The axe comes from grave 26 of the highly significant cemetery in Mikulovice. It probably belonged to a male who was buried with the axe that had remains of wood on it as well as with a bronze dagger, an Únětice pin, and a bone awl (for details see Ernée et al. 2020).

2 For more information see Moucha 2005; Vachta 2016; Chvojka et al. 2017.

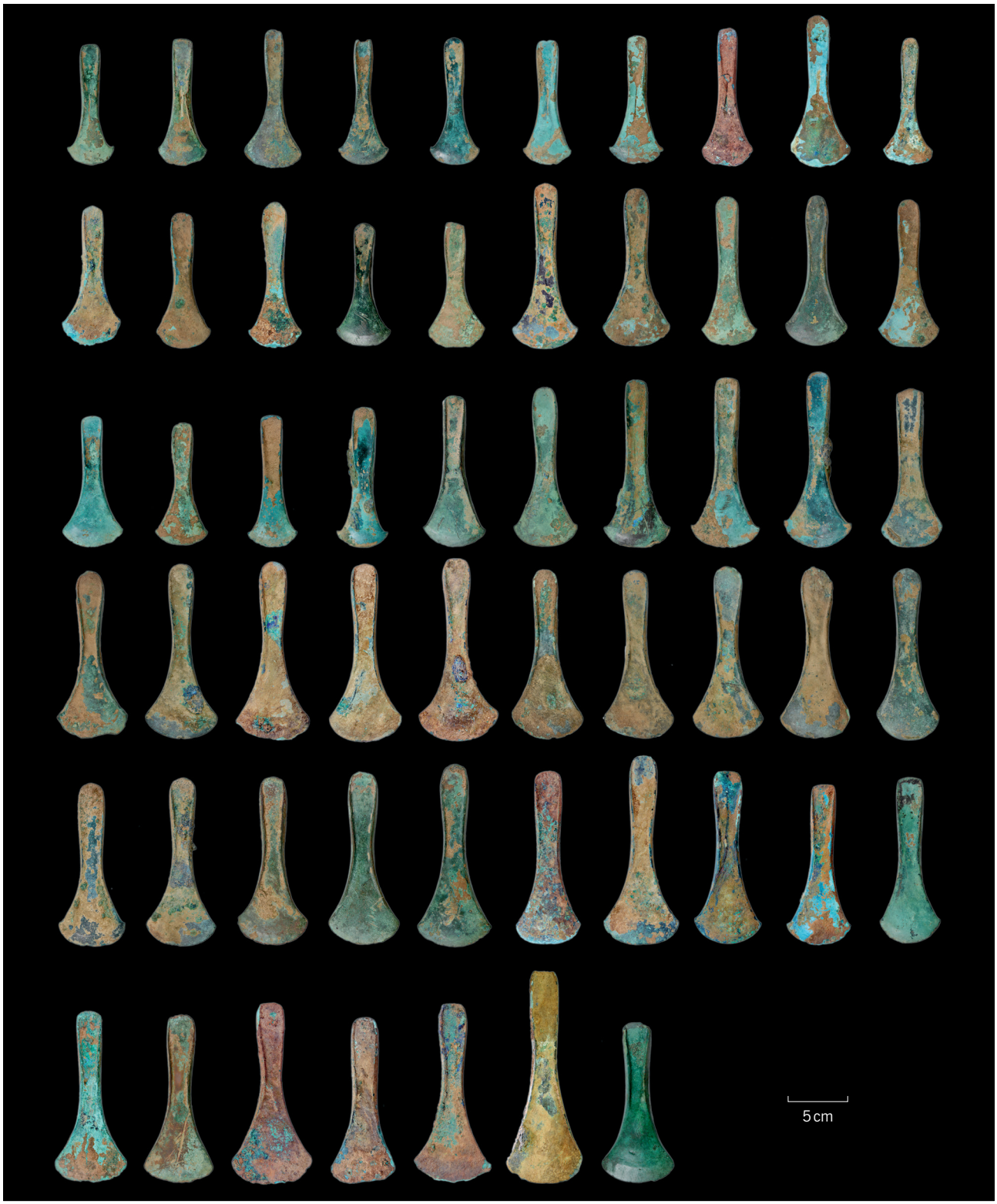

Fig. 3 The hoard from Kukleny, Hradec Králové district.

Abb. 3 *Der Hort von Kukleny, Okr. Hradec Králové.*

Axes from settlement features

Finds of axes from stratified situations are extremely rare. Only two axes have been found so far, and both specimens were small fragments: In the case of Lochenice, Hradec Králové district, it was a butt of an axe; and in case of Domašín, Rychnov nad Kněžnou district, it was the central part (Fig. 8). These small fragments are most probably pieces that were meant to be used for recasting, but for some reason they ended up in rubbish pits. These fragments could confirm that axes were used at the settlements where they were found.

Fig. 4 The hoard from Kunčice, Hradec Králové district.

Abb. 4 *Der Hort von Kunčice, Okr. Hradec Králové.*

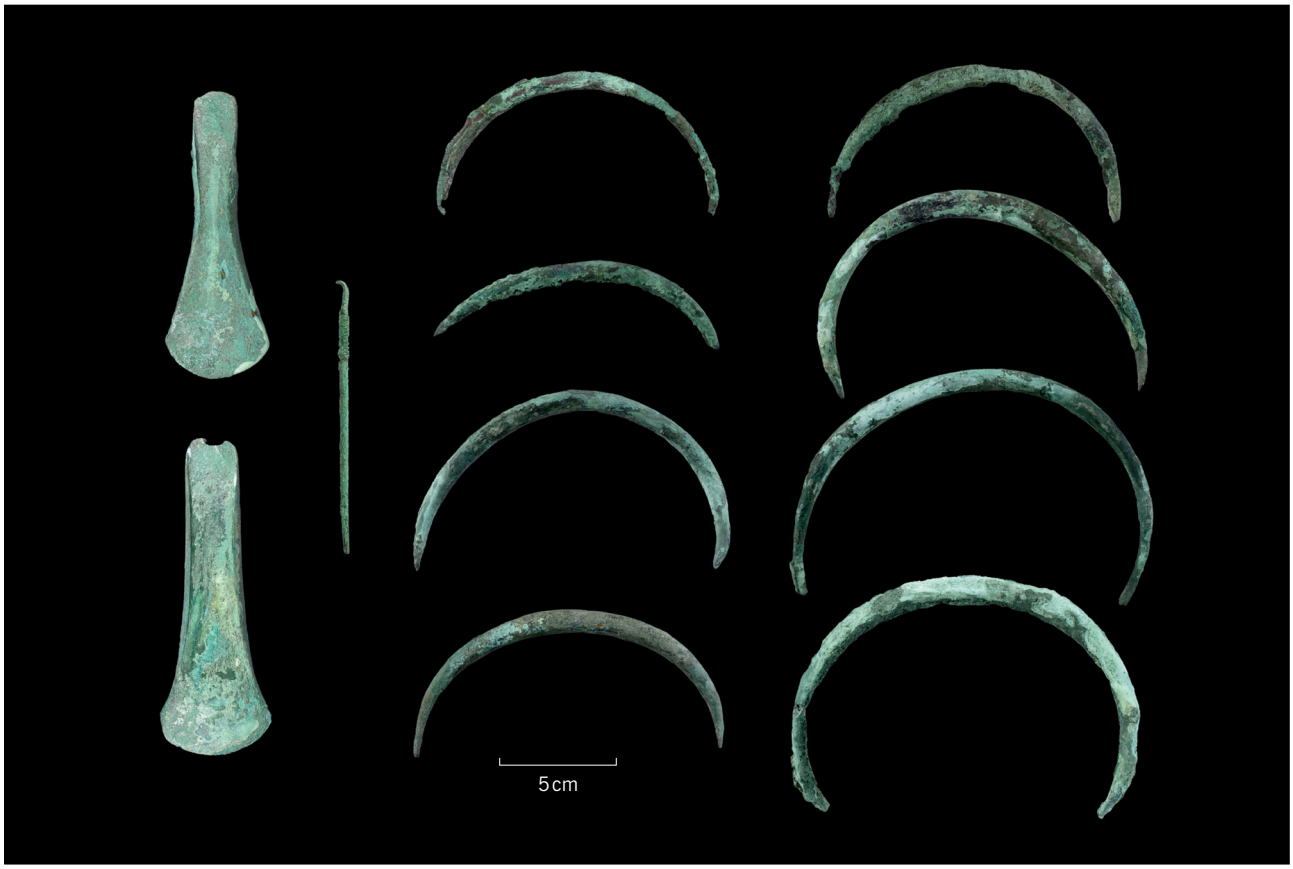

Fig. 5 The hoard from Těchlovice, Hradec Králové district.

Abb. 5 *Der Hort von Těchlovice, Okr. Hradec Králové.*

Single finds

These are the most frequent types of finds. In total, there are 25 of them (Fig. 9). Usually, they were found by metal detectorists, and the only information we have are the coordinates. Here the most important information is about the spatial distribution of axes within the studied region (see Fig. 1). These solitary finds make connections where there is

Fig. 6 The hoard from Loučná Hora, Hradec Králové district.

Abb. 6 *Der Hort von Loučná Hora, Okr. Hradec Králové.*

Fig. 7 The hoard from Dolany, Jičín district.

Abb. 7 *Hort von Dolany, Okr. Jičín.*

no previous find of the Únětice Culture. Whether these axes represent a lost item or were originally part of grave goods (most probably a hoard) remains unknown.

Hammers

A special category is represented by axe-shaped artefacts that are usually referred to as hammers, although their actual function remains unclear (Fig. 10). In the eastern Bohemian assemblage, these are represented by two specimens. The first comes from the hoard of Jičíněves, the other is a single find from Předměřice that was recovered in the 19th century.

Fig. 8a–b Fragments of axes from settlement features. a Lochenice, Hradec Králové district, axe no. 2370; b Domašín, Hradec Králové district.

Abb. 8a–b *Beilfragmente aus Siedlungsbefunden. a Lochenice, Okr. Hradec Králové, Beil-Nr. 2370; b Domašín, Okr. Hradec Králové.*

Methods

Each artefact was documented and analysed in a standardised process to obtain similar and comparable data from each sample. All the analyses performed were designed to be as non-invasive as possible. This excluded metallographical sections and the drilling of samples for elemental composition from the outset. The decision provided an opportunity to develop a set of minimally-invasive analyses summarised below.

The *elemental composition analysis* was done with a Scanning Electron Microscope (SEM; Tescan VEGA 3 LMU)

Fig. 9 Axes from settlement features. 1 Čistěves, axe no. 2034; 2 Čistěves, axe no. 2035; 3 Dobruška; 4 Dražkov, axe no. A012023; 5 Dražkovice, axe no. AR016337; 6 Horní Jelení, axe no. AR016752; 7 Chlumec nad Cidlinou, axe no. 98398; 8 Kostelec; 9 Lázně Bohdaneč, axe no. AR010156; 10 Libišany, axe no. B148124; 11 Litošice; 12 Lochenice, axe no. A95781; 13 Měník, axe no. 5_2017; 14 Miletín; 15 Nízká Srbská; 16 Plotiště nad Labem, axe no. A80637; 17 Předměřice nad Labem, axe no. 1802; 18 Strašov, axe no. AR012049; 19 Třebechovice, axe no. 58_1972; 20 Valdice axe no. 30695; 21 Velká Čermná; 22 Voleč, axe no. 12055; 23 Vršce, axe no. 96684; 24 Vysoké Chvojno, axe no. AR011868; 25 Žáravice, axe no. AR012065.

Abb. 9 *Beile aus Siedlungsbefunden. 1 Čistěves, Beil-Nr. 2034; 2 Čistěves, Beil-Nr. 2035; 3 Dobruška; 4 Dražkov, Beil-Nr. A012023;5 Dražkovice, Beil-Nr. AR016337; 6 Horní Jelení, Beil-Nr. AR016752; 7 Chlumec nad Cidlinou, Beil-Nr. 98398; 8 Kostelec; 9 Lázně Bohdaneč, Beil-Nr. AR010156; 10 Libišany, Beil-Nr. B148124; 11 Litošice; 12 Lochenice, Beil-Nr. A95781; 13 Měník, Beil-Nr. 5_2017; 14 Miletín; 15 Nízká Srbská; 16 Plotiště nad Labem, Beil-Nr. A80637; 17 Předměřice nad Labem, Beil-Nr. 1802; 18 Strašov, Beil-Nr. AR012049; 19 Třebechovice, Beil-Nr. 58_1972; 20 Valdice, Beil-Nr. 30695; 21 Velká Čermná; 22 Voleč, Beil-Nr. 12055; 23 Vršce, Beil-Nr. 96684; 24 Vysoké Chvojno, Beil-Nr. AR011868; 25 Žáravice, Beil-Nr. AR012065.*

Fig. 10a–b The axe-shaped hammers. a Jičíněves, Jičín district, no. A162; b Předměřice nad Labem, Hradec Králové district, no. 1803.

Abb. 10a–b *Die beilförmigen Hämmer. a Jičíněves, Okr. Jičín, Nr. A162; b Předměřice nad Labem, Okr. Hradec Králové, Nr. 1803.*

with Energy Dispersive Spectroscopy (EDS; Oxford Instruments INCA 350). The analysis of the elemental composition required minor intervention on the surface, which was necessary because measurements of the corrosion products tend to show increased concentrations of certain elements. This method should be regarded as semi-quantitative; its limits are in measuring the very low concentrations of elements, and the results are not as precise as samples taken from the core. We took advantage of minor damages caused by ploughing or corrosion, and we polished the surface to uncover the metal core[3]. The aim was to determine whether the axes consisted of copper or bronze and what the percentage of tin in the alloy was. In addition to the tin content, the focus was on the content of silver in the matrix in order to exclude the possibility of silver enrichment of the surface as a result of corrosion.

The *metalwork wear analysis*[4] was performed using a trinocular microscope with transmitted direct illumination providing up to 200x magnification and a binocular magnifier with side illumination. Optical microscopy was complemented using the Olympus DSX1000 opto-digital microscope, Reflectance Transformation Imaging (RTI), and thorough macro-photo documentation on selected pieces. The combination of optical methods and the utilised magnification helps to capture and document all kinds of damage and traces on the surface of the artefact, from macro-scale to the finest details.

The *analysis of the silver coating* was the result of combining the previously described methods. Thorough documentation of the surfaces coated with silver was done by equipment used for the metalwork wear analysis; selected samples were documented by digital microscope to obtain two- and three-dimensional images under visible light (Keyence VHX 7000 Elemental Analyzer). The character of the layers and their composition was documented and analysed by SEM-EDS, and selected samples were examined using Laser Induced Plasma Spectroscopy (LIPS, using a Keyence VHX 7000 EA) to further determine their character and thickness. To exclude the possibility that the silver layers were the result of corrosion of the matrix and to prove that could be in fact an applied layer of metallic silver, we conducted X-Ray Diffraction (XRD; diffractometer PANanalytical X'pert PRO).

The information was gathered not only from the surface, but also from the *internal structure*. Each axe was X-rayed to obtain information about possible casting defects (with Explorer X-test 200-120/400 by Testima), and a few selected samples were analysed with Computer Tomography (CT; TORATOM – Twinned Orthogonal Adjustable Tomograph).

Here we have to stress that the level of information gained from the surface is strongly influenced by the conservation practice. The silver coating turned out to be best preserved on axes that did not go through any conservation treatment and were not mechanically cleaned. Some axes also bore traces of harsh mechanical cleaning that not only destroys the silver layers but also any traces of manufacture and use. Solutions used for conservation (organic polymers dissolved in solvents) are also problematic. They can cover the surface so densely that its study is often impossible. In consequence, some samples had to be excluded from some of the analyses (Fig. 11).

Results

Elemental composition

The results of the SEM-EDS elemental composition analysis show that the majority of the axes, regardless of the context, were cast from copper with different amounts of tin. The measured range of tin was between 1.3 and 13.1 wt%, whereas silver was between 0.1 and 2.9 wt%. This allowed us to observe three main variants (Tab. 1). The first are axes consisting of fahlore copper without any added tin. This composition is similar to the so-called Ösenring copper (Junk et al. 2001). Another variant are axes of fahlore copper to which high amounts of tin had been added. The natural content of tin in tetrahedrite ores is in the tenths of 1 wt%, implying that tin was definitely added intention-

3 This minor invasive treatment was approved by the lending institutions.

4 Since the analysis includes not only use-wear traces but also manufacturing marks and potential repairs, which often predominate on metal artefacts, we use the term »metalwork wear analysis« as established by A. Dolfini and R. Crellin in their 2016 study (Dolfini/Crellin 2016).

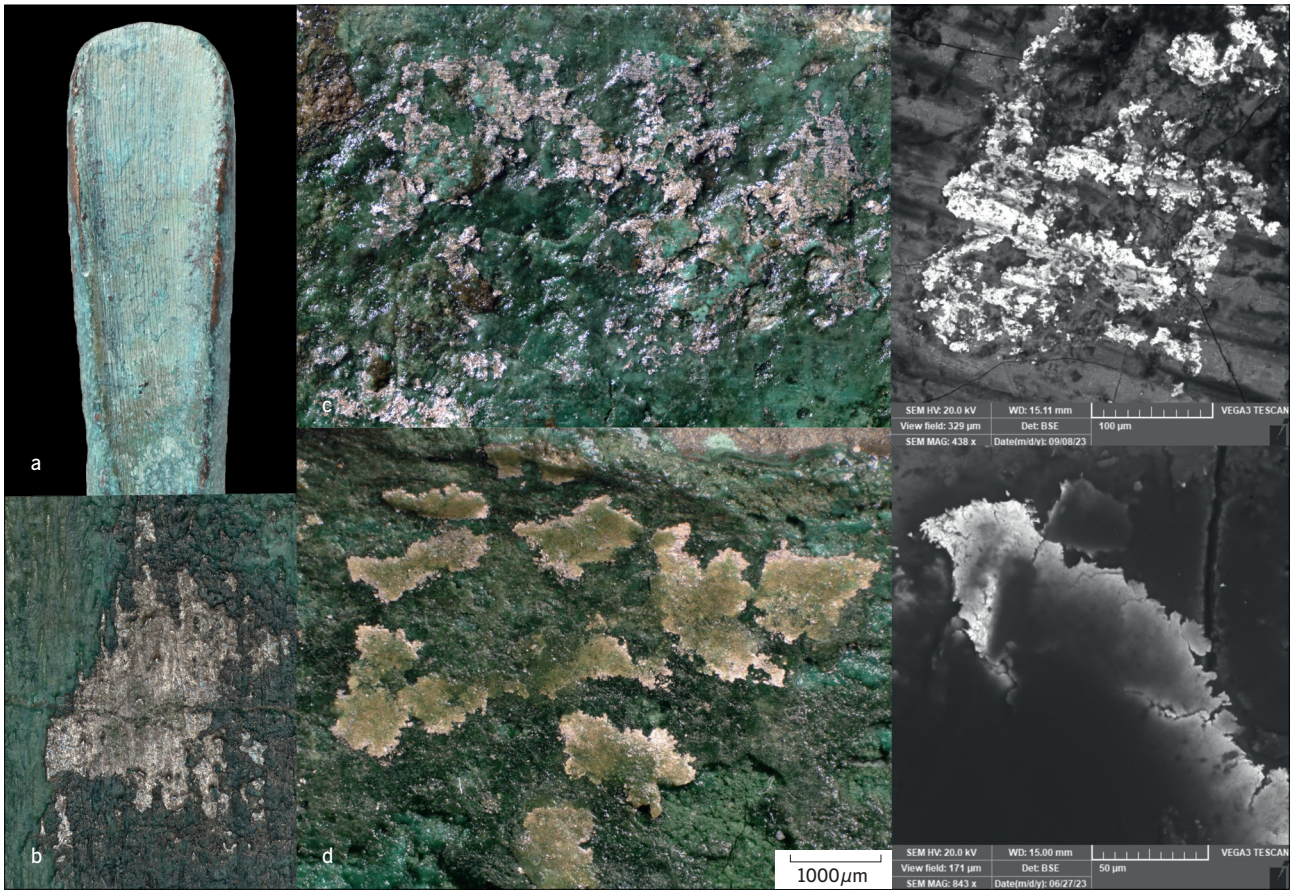

Fig. 11a–d Results of inappropriate conservation procedures. a Traces of harsh mechanical cleaning, probably with metal brush; b Traces of harsh mechanical cleaning, probably with metal brush over the silver coating (optical microscopy); c Traces of harsh mechanical cleaning that completely destroyed all the polishing traces on copper and silver (optical microscopy and SEM); d Remains of conservation solution that covered the silver coating remains and degraded into a yellow colour (optical microscopy and SEM).

Abb. 11a–d *Ergebnisse ungeeigneter Konservierungsverfahren. a Spuren grober mechanischer Reinigung, vermutlich mit einer Drahtbürste; b Spuren grober mechanischer Reinigung, vermutlich mit einer Drahtbürste auf der Silberbeschichtung; c Spuren grober mechanischer Reinigung, die sämtliche Polierspuren auf Kupfer und Silber vollständig zerstört hat (Licht- und Rasterelektronenmikroskopie [REM]); d Reste einer Konservierungslösung, welche die Überreste der Silberbeschichtung bedeckt und sich gelblich verfärbt hat (Lichtmikroskopie und REM).*

ally (George et al. 2017). In the remaining axes, the majority of elements were below the detection limit of the applied method; the only measurable elements were copper, tin, and, in few cases, also lead.

In the case of the large hoard from Kukleny, only 13 of 57 axes did not contain intentionally added tin. The range of tin in the remaining 44 specimens varied between 1.3 and 11.4 wt%. The range of silver in 49 axes varied between 0.4 and 2.7 wt%. In the remaining eight cases, silver was below the detection limit of the applied method (Schimerová et al. 2023, Tab. 1).

The results show a clear preference for axes made of bronze. Although there are axes made of fahlore copper with no added tin, in the entire assemblage they form a minority. Taking all hoards together, from the total number of 83 axes, 15 were made of copper (13 from Kukleny and two from the hoard of Loučná Hora). The axe from the Mikulovice grave was made of bronze with high tin content, and so were the axes from settlement situations. In case of the single finds, from the total number of 25, eleven axes were made of copper. Of the two hammers, one was made of copper and one of bronze.

Metalwork wear analysis

The metalwork wear analysis was systematically applied to the whole studied assemblage. This surface analysis is indispensable for a comprehensive understanding of the significance/meaning of artefacts, providing a new perspective on both objects and the activities themselves (e.g., Dolfini/Crellin 2016; Dolfini et al. 2023; Hermann et al. 2020). The methodology was established by T. L. Kienlin and B. S. Ottaway (1998), and, with modifications or additions, these steps are still in use today[5].

There are two basic groups of traces – manufacture and use – that must first be distinguished from each other. In the case of bronze objects, other traces can be distin-

5 E.g., Crellin 2018; Dolfini et al. 2023; Dolfini/Crellin 2016; Kienlin 2004; Molloy et al. 2016; Roberts/Ottaway 2003; Sáez/Lerma 2015; Sych 2014.

Site	Arch. ID	Context	Sn	Ag	Sb	Bi	As	Pb	Ni	Cu
Kukleny	79435	Hoard	4.6	0.7	-	-	-	-	-	94.7
Kukleny	79436	Hoard	2.9	-	-	-	-	-	-	97.1
Kukleny	79437	Hoard	0.9	1.0	0.8	-	-	-	0.4	96.9
Kukleny	79438	Hoard	3.7	1.1	0.6	-	-	0.2	-	94.4
Kukleny	79439	Hoard	4.1	-	-	-	0.3	-	-	95.6
Kukleny	79440	Hoard	6.3	0.6	0.4	-	-	-	-	92.7
Kukleny	79441	Hoard	5.0	-	-	-	-	-	-	95.0
Kukleny	79442	Hoard	6.9	1.0	0.7	-	1.4	-	-	90.0
Kukleny	79443	Hoard	11.4	0.4	-	-	-	-	-	88.2
Kukleny	79444	Hoard	3.1	-	-	-	-	-	-	96.9
Kukleny	79445	Hoard	3.8	0.7	0.4	-	-	-	-	95.1
Kukleny	79446	Hoard	4.5	1.0	0.6	-	1.1	-	-	92.8
Kukleny	79447	Hoard	5.2	0.8	0.4	-	-	-	-	93.6
Kukleny	79448	Hoard	4.9	0.6	-	-	-	-	-	94.5
Kukleny	79449	Hoard	1.3	-	-	-	-	-	-	98.7
Kukleny	79450	Hoard	2.7	0.7	-	-	-	-	-	96.6
Kukleny	79451	Hoard	7.4	1.8	0.5	-	0.9	-	-	89.4
Kukleny	79452	Hoard	4.9	0.6	0.3	-	-	-	-	94.2
Kukleny	79453	Hoard	0.6	1.8	2.3	0.3	2.7	-	-	92.3
Kukleny	79454	Hoard	6.1	1.4	1.0	-	1.9	-	-	89.6
Kukleny	79455	Hoard	6.7	-	-	-	-	-	-	93.3
Kukleny	79456	Hoard	4.4	1.1	0.7	-	0.3	-	-	93.5
Kukleny	79457	Hoard	7.6	0.4	0.6	-	-	-	-	91.4
Kukleny	79458	Hoard	5.3	0.5	-	-	-	-	-	94.2
Kukleny	79459	Hoard	6.0	0.8	-	-	-	-	-	93.2
Kukleny	79460	Hoard	5.2	0.5	0.5	-	-	-	-	93.8
Kukleny	79461	Hoard	3.9	0.6	0.6	-	-	-	-	94.9
Kukleny	79498	Hoard	3.1	0.7	-	-	-	-	-	96.2
Kukleny	79462	Hoard	5.4	0.6	-	-	-	-	-	94.0
Kukleny	79463	Hoard	2.8	1.0	0.8	-	1.8	-	-	93.6
Kukleny	79464	Hoard	0.4	1.5	1.2	-	1.1	-	-	95.8
Kukleny	79465	Hoard	1.3	0.9	1.2	-	1.7	-	-	94.9
Kukleny	79466	Hoard	-	1.6	2.1	-	2.9	-	-	93.4
Kukleny	79467	Hoard	-	1.3	1.3	-	1.1	-	-	96.3
Kukleny	79468	Hoard	-	1.2	0.9	-	1.2	-	-	96.7
Kukleny	79469	Hoard	-	1.9	1.2	-	1.2	-	-	95.7
Kukleny	79470	Hoard	-	2.2	1.5	-	2.0	-	-	94.3
Kukleny	79471	Hoard	-	1.9	1.7	-	3.1	-	-	93.3
Kukleny	79472	Hoard	-	1.6	1.9	-	1.0	-	-	95.5
Kukleny	79473	Hoard	-	0.6	0.7	-	0.9	-	-	97.8
Kukleny	79474	Hoard	2.3	1.0	0.6	-	0.7	-	-	95.4
Kukleny	79475	Hoard	1.4	1.3	0.6	-	1.4	-	-	95.3
Kukleny	79476	Hoard	-	1.5	0.9	0.2	1.5	-	-	95.9
Kukleny	79477	Hoard	-	1.3	1.7	-	2.2	0.2	-	94.6
Kukleny	79478	Hoard	3.6	1.4	1.1	-	1.9	-	-	92.0
Kukleny	79479	Hoard	-	2.7	1.7	-	-	-	1.8	93.8
Kukleny	79480	Hoard	-	1.2	1.0	-	1.4	-	-	96.4

Silver coating	Weight	Length	Edge width	Central width	Butt width	Thickness
x	200.7	121	47	18	19	16
?	171.2	121	46	18	19	13
x	193.4	133	56	14	17	12
x	206.1	126	51	16	18	14
x	219.1	135	53	17	20	14
x	170.7	118	46	17	20	13
x	213.5	123	52	17	18	15
x	196.6	131	48	17	17	14
x	258.3	139	56	17	18	15
?	172.6	125	49	14	15	14
?	207.7	122	53	18	18	14
x	203.7	124	50	17	19	15
?	212.5	130	49	15	21	17
?	179.9	119	52	17	20	14
?	162.0	114	52	16	18	13
?	208.2	140	56	16	19	15
x	228.2	135	58	18	20	14
x	193.9	128	48	17	19	13
x	191.9	136	56	18	15	13
x	186.6	127	53	17	17	14
x	185.7	112	53	17	18	14
x	139.2	108	46	14	17	12
x	170.5	113	43	16	18	15
x	176.2	120	43	19	18	14
x	191.3	128	53	18	19	13
x	181.8	133	54	16	18	13
x	254.4	140	56	19	18	16
x	216.8	136	55	18	19	14
x	237.3	146	58	15	19	14
x	207.2	128	50	19	22	14
x	191.0	139	59	17	20	11
-	197.0	145	61	15	20	13
-	201.7	141	59	17	21	13
?	188.1	135	55	17	20	12
-	185.4	136	59	16	20	13
x	174.0	131	56	22	19	11
-	198.3	136	57	18	19	12
?	187.2	134	56	16	22	12
?	178.4	135	55	18	25	12
?	183.4	136	50	17	22	13
-	193.2	132	54	18	21	9
?	198.0	130	54	17	20	14
-	181.7	128	53	17	19	13
-	183.6	131	54	18	20	12
?	216.1	137	56	17	19	11
x	170.7	132	50	17	20	11
x	207.4	145	58	17	20	12

Tab. 1 Overview of elemental composition results, presence of silver coating, and measurements of studied axes. The elemental composition was measured by SEM-EDS, the silver coating by SEM-EDS and XRD, the weight is measured in grams, size measurements in millimetres. The presence of silver-coating is marked with ›x‹; in case the coating was not visible by optical microscopy with 200x magnification and visible only with SEM its marked as questionable with ›?‹; in case its not present at all, it marked with ›-‹; measurements of axes that were not available for examination are marked as not available (N/A.)

Tab. 1 *Überblick über die Elementzusammensetzung, das Vorhandensein einer Silberbeschichtung und die Maße der untersuchten Beile. Die Elementzusammensetzung wurde mittels Rasterelektronenmikroskopie/energiedispersiver Röntgenspektroskopie (REM-EDX) bestimmt, die Silberbeschichtung mittels REM-EDX und Röntgenbeugung (XRD); das Gewicht ist in Gramm angegeben, die Größenangaben in Millimetern. Das Vorhandensein einer Silberbeschichtung ist mit ›x‹ gekennzeichnet; wenn die Beschichtung bei der optischen Mikroskopie mit 200-facher Vergrößerung nicht sichtbar war und nur im REM sichtbar ist, wird sie mit ›?‹ als fraglich gekennzeichnet; wenn sie überhaupt nicht vorhanden ist, mit ›-‹; Messungen an Beilen, die für die Prüfung nicht zur Verfügung standen, werden als nicht verfügbar (N/A) gekennzeichnet.*

Site	Arch. ID	Context	Sn	Ag	Sb	Bi	As	Pb	Ni	Cu
Kukleny	79481	Hoard	-	1.2	1.6		1.4			95.8
Kukleny	79482	Hoard	5.5	0.4	0.3	-	-	-	-	93.8
Kukleny	79483	Hoard	7.1	1.1	-	-	-	-	-	91.8
Kukleny	79484	Hoard	3.4	1.1	-	-	-	-	-	95.5
Kukleny	79485	Hoard	1.2	2.3	4.9	4.5	2.0	-	-	85.1
Kukleny	79486	Hoard	1.8	1.4	0.9	-	1.6	-	-	94.3
Kukleny	79487	Hoard	1.3	0.5	0.5	-	0.7	-	-	97.0
Kukleny	79488	Hoard	2.3	-	-	-	-	-	-	97.7
Kukleny	79489	Hoard	3.3	-	-	-	-	-	-	96.7
Kukleny	79490	Hoard	4.0	0.6	0.4	-	-	-	-	95.0
Kunčice	82441	Hoard	11.5	-	-	-	-	-	-	88.5
Kunčice	82442	Hoard	10.0	-	-	-	-	-	-	90.0
Kunčice	82443	Hoard	12.1	-	-	-	-	1.2	-	86.7
Kunčice	82444	Hoard	11.8	-	-	-	-	1.5	-	86.7
Kunčice	82445	Hoard	7.0	1.0	1.0	-	-	-	-	91.0
Kunčice	82446	Hoard	8.2	-	-	-	-	-	-	91.8
Kunčice	82447	Hoard	5.5	-	-	-	-	-	-	94.5
Kunčice	82448	Hoard	10.3	-	-	-	-	3.0	-	86.7
Jičíněves	6824	Hoard	5.5	-	-	-	-	-	-	94.5
Jičíněves	14799	Hoard	3.2	0.1	0.7	-	-	-	-	96.0
Jičíněves	52271	Hoard	5.4	0.7	0.3	-	0.7	-	-	92.9
Jičíněves	A161	Hoard	6.2	1.2	0.7	-	-	-	-	91.9
Jičíněves	A163	Hoard	1.4	0.9	-	-	0.7	-	-	97.0
Jičíněves	A165	Hoard	1.7	1.5	0.5	-	1.0	-	-	95.3
Jičíněves	19	Hoard	3.6	0.6	0.6	-	0.3	-	-	94.9
Jičíněves	710	Hoard	4.1	0.6	0.7	-	0.7	-	-	93.9
Obora	1	Hoard	5.9	0.9	0.6	-	-	-	-	92.6
Obora	2	Hoard	2.9	-	-	-	-	-	-	97.1
Obora	3	Hoard	2.7	0.7	0.6	-	1.6	-	-	94.4
Těchlovice	A74795	Hoard	5.2	0.5	0.6	-	0.3	-	-	93.4
Těchlovice	A74800	Hoard	12.4	0.9	1.0	-	-	-	-	85.7
Loučná Hora	A81007	Hoard	-	1.7	1.2	-	-	-	-	97.1
Loučná Hora	A81008	Hoard	-	0.8	1.0	-	0.8	-	1.5	95.9
Dolany	96953	Hoard	9.6	0.7	-	-	-	-	-	89.7
Staré Místo	-	Hoard	3.0	-	-	-	-	-	-	97.0
Starý Bydžov	522_6	Hoard	1.4	2.1	1.4	-	-	-	1.5	93.6
Mikulovice	4920	Grave	12.5	-	-	-	-	-	-	87.5
Domašín	-	Settlement	-	-	-	-	-	-	-	-
Lochenice	2370	Settlement	6.0	1.5	1.4	-	2.4	-	-	88.7
Čistěves	2034	Single find	-	1.8	0.8	-	0.9	-	-	96.5
Čistěves	2035	Single find	-	2.4	0.5	-	0.6	-	-	96.5
Dobruška	-	Single find	1.9	2.0	1.7	-	-	-	1.9	92.5
Dražkov	A012023	Single find	10.1	-	-	-	-	-	0.7	89.2
Dražkovice	AR016337	Single find	5.2	1.1	-	-	-	-	-	93.7

Silver coating	Weight	Length	Edge width	Central width	Butt width	Thickness
?	176.7	131	51	17	22	13
x	191.6	121	49	17	18	13
x	171.6	124	46	17	19	12
x	198.8	131	56	17	19	13
?	188.7	132	55	18	21	12
x	188.5	134	60	16	20	12
x	167.1	124	48	19	17	11
-	190.1	134	57	16	18	13
?	243.4	167	60	21	22	11
x	216.8	126	57	20	22	14
?	401.1	196	64	27	32	10
?	361.0	178	66	30	26	13
?	389.5	195	64	26	27	12
?	309.0	150	60	23	25	12
x	170.2	125	48	15	18	15
?	187.9	120	43	24	22	11
?	166.0	122	46	15	19	13
?	142.0	154	45	16	16	7
N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A
-	N/A	N/A	N/A	N/A	N/A	N/A
?	75.8	70	-	15	19	13
?	177.5	100	53	19		14
?	207.6	142.5	53	19	18	12
-	N/A	N/A	N/A	N/A	N/A	N/A
-	N/A	N/A	N/A	N/A	N/A	N/A
?	271.7	142	56	16	22	16
?	209.0	135	46	17	21	15
?	212.1	147	54	15	19	14
x	230.0	138	51	21	22	19
x	311.3	151	52	27	25	14
x	215.0	122	53	18	20	16
x	77.8	83	29	15	12	12
?	168.0	152	51	17	17	9
?	231.7	151	56	15	20	13
?	128.1	102	47	16	17	12
-	99.3	133	34	15	15	9
-	6.0	17	-	-	-	5
-	16.2	23	-	-	19	9
?	186.8	101	51	17	19	14
?	182.3	115	-	16	15	16
x	320.9	147	63	20	22	16
-	108.4	94	43	23	15	9
x	116.9	107	46	19	16	10

Site	Arch. ID	Context	Sn	Ag	Sb	Bi	As	Pb	Ni	Cu
Horní Jelení	AR016752	Single find	9.0	-	-	-	-	-	-	91.0
Chlumec nad Cidlinou	98398	Single find	-	1.1	1.1	-	-	-	1.4	96.4
Kostelec	-	Single find	-	1.4	1.2	-	-	-	1.3	96.1
Lázně Bohdaneč	AR010156	Single find	-	1.5	0.6	-	-	-	-	97.9
Libišany	B148124	Single find	13.1	-	-	-	-	-	-	86.9
Litošice	-	Single find	6.1	-	0.5	-	-	-	-	93.4
Lochenice	95781	Single find	-	1.2	1.9	-	-	-	1.8	95.1
Měník	5_2017	Single find	-	2.1	0.9	-	-	-	1.7	95.3
Miletín	-	Single find	-	1.3	3.2	-	1.7	-	3.0	90.8
Nízká Srbská	-	Single find	5.8	1.1	1.0	-	-	-	-	92.1
Plotiště nad Labem	A80637	Single find	-	1.4	2.0	-	-	-	1.8	94.8
Předměřice nad Labem	1802	Single find	3.7	0.5	-	-	-	-	-	95.8
Strašov	AR012049	Single find	-	0.9	1.5	-	1.2	-	2.9	93.5
Třebechovice	58_1972	Single find	2.0	2.0	1.4	-	-	-	-	94.6
Valdice	30695	Single find	-	2.3	0.8	-	-	-	-	96.9
Velká Čermná	-	Single find	-	-	-	-	-	0.6	-	99.4
Voleč	AR012055 AR 010256	Single find	11.8	-	-	-	-	-	-	88.2
Vršce	96684	Single find	-	-	-	-	1.4	-	3.9	94.7
Vysoké Chvojno	AR011868	Single find	9.8	-	-	-	1.1	-	1.3	97.8
Žáravice	AR012065	Single find	-	1.9	2.1	-	1.2	-	0.5	94.3
Jičíněves	A162	Hammer	4.2	1.1	0.6	-	-	-	-	94.1
Předměřice nad Labem	1803	Hammer	1.9	2.9	0.7	-	-	-	-	94.5

guished, which have also been described, such as manipulation wear, repairs, post-depositional traces, and traces of recent origin (Schimerová et al. 2023). Only then can a more detailed interpretation of the individual traces occur, which is necessarily associated with controlled experiments (Dolfini et al. 2023; Hermann et al. 2020; Roberts/Ottaway 2003). Experimental verification (a controlled experiment) can identify a certain type of damage with a specific activity (Dolfini et al. 2023). However, in the case of axes, we still encounter insufficient experimental data, especially for the interpretation of the often-present random striations and grooves.

These fine traces are very challenging to interpret, but repetitive so-called manipulative traces[6] can be observed, making their origin more likely to be identified. Repairs that are observable and recorded on artefacts but that prevent or distort knowledge of practical use are also an important factor. Recycling, repairs (including resharpening), and rapid metal loss could also be reasons why metalwork wear analysis as a method began to be applied relatively late compared to the original use-wear analysis in the stone artefacts (Roberts/Ottaway 2003).

The informative potential of most of the examined axes from eastern Bohemia was limited for metalwork wear

6 E.g., Schimerová et al. 2023; M. Havlíková, Sword-fighting in Bronze Age Europe: assessing the use of bronze swords from Bohemia and Moravia. AWRANA Barcelona 2022 Congress, <https://www.academia.edu/81152164/Sword_fighting_in_Bronze_Age_Europe_assessing_the_use_of_bronze_swords_from_Bohemia_and_Moravia> (28.05.2024).

Silver coating	Weight	Length	Edge width	Central width	Butt width	Thickness
-	197.3	152	41	26		12
-	226.0	101	39	26	19	15
?	33.6	40	-	-	15	11
-	66.8	51	33	17		11
-	195.0	129	44	20	18	13
-	114.2	156	43	19	20	9
?	60.0	53	36	14	-	11
?	103.5	90	35	16	18	13
?	106.4	89	37	18	19	12
x	77.8	96	36	13	11	11
?	72.3	76	34	14	14	10
?	193.1	121	51	17	19	14
?	165.2	109	45	23	22	13
?	242.5	117	50	27	23	14
?	158.4	113	38	15	14	15
-	93.0	57	45	-	-	12
-	94.2	109	30	17	16	8
-	66.4	124	40	14	16	7
-	56.0	89	25	14	12	10
?	60.5	45	38	-	-	10
?	172.3	99	36	20	13	12
x	273.2	101	48	22	21	14

analysis due to conservation and mechanical cleaning. The main issue in this case is the removal of patina, which serves as an indicator of the age of the trace, as well as conservation solutions, through which the surface of the artefact cannot be analysed (Fig. 11).

Despite conservation, it was possible to identify some use-wear traces on nearly all axes from eastern Bohemia (Fig. 12). Most specimens feature multiple traces, including striations running at an angle to the cutting edge, blade blunting, and flattening of the cutting edge. Overall, these traces are compatible with woodworking activities[7]. At the same time, traces of forging, grinding, and the sharpening of the blade are often present. Resharpening the blades is very common, demonstrating repeated (frequent) use of the axe. It is indicated by various degrees of asymmetry of the blade and metal loss (Dolfini et al. 2023; Dolfini 2011; Moyler 2008). Resharpening the blade results in the loss of traces of use in this area, so whether the axe was used can be observed based on the asymmetry of the blades and the presence of manipulative traces on the surface. The intensity of use based on the asymmetry of the blade and the loss of metal (see Moyler 2008) is then influenced by the mechanical properties of the metal, namely, the elemental composition and hardness of the blade due to forging. The

7 Crellin 2018; Dolfini et al. 2023; Dolfini 2011; Kienlin/Ottaway 1998; Roberts/Ottaway 2003; Schimerová et al. 2023.

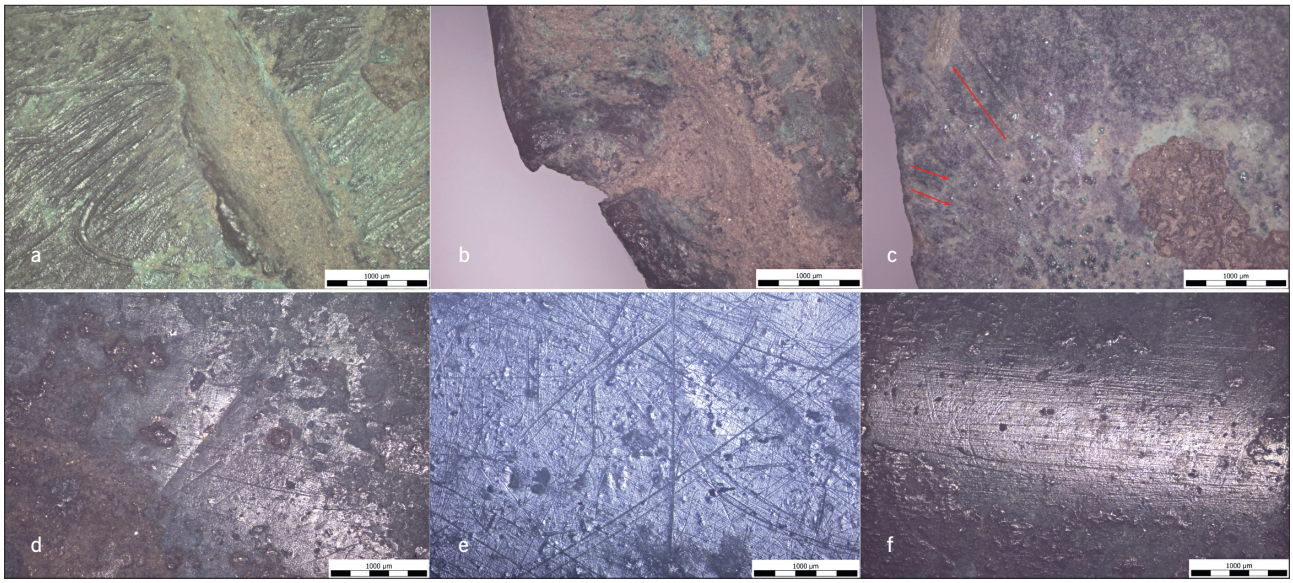

Fig. 12a–f Representation of metalwork wear traces. a Massive cut mark on the flange of axe, Kukleny, Hradec Králové district, axe no. 79484; b Damage of edge (cut with the surrounding metal) from impacts with a harder material, Kukleny, axe no. 79461; c Oblique grooves on the edge, Kukleny, axe no. 79453; d Manipulative traces on the blade, Nízká Srbská, Náchod district; e Manipulative traces with a dent on the blade, Kunčice; f Polishing of the flange, Staré Místo, Jičín district. Magnified 50x.

Abb. 12a–f *Beispiele für Abnutzungsspuren auf Metall. a Starke Schnittspur auf der Randleiste eines Beils, Kukleny, Okr. Hradec Králové, Beil-Nr. 79484; b Beschädigung der Schnittkante (einschließlich des umgebenden Metalls) durch Zusammenstöße mit einem härteren Material, Kukleny, Beil-Nr. 79461; c Schräge Kerben auf der Schneide, Kukleny, Beil-Nr. 79453; d Nutzungsspuren auf der Klinge, Nízká Srbská, Okr. Náchod; e Nutzungsspuren und eine Delle auf der Klinge, Kunčice; f Polierspuren auf der Randleiste, Staré Místo, Okr. Jičín. Fünfzigfache Vergrößerung.*

Fig. 13 Documented degrees of metal loss on the blade from probably new (or only briefly used and once repaired) to almost complete blade disappearance.

Abb. 13 *Metallschwund an der Klinge von vermutlich neu (oder nur kurz benutzt und einmal repariert) bis zum fast vollständigen Abtrag.*

symmetry of the blade is often distorted due to the condition of the axe, particularly because of corrosive processes. It is essential to consider the cutting edge condition in the analysis and exclude corrosion as the cause of traces and damage during the interpretation (Horn/Holstein 2017). Among the axes analysed within our dataset, we can observe all degrees of metal loss on the blade, ranging from the probably new (or only briefly used and once repaired) blade to almost complete blade disappearance (Fig. 13).

In the corrosion layers, organic residues are often present as well. In the case of the axes, these are primarily remnants of wooden hafts in the area of the hafting. For example, in the case of Kukleny, we can observe attachment points due to manipulative traces corresponding to contact with wood (Fig. 14a). On an axe from grave 26 from Mikulovice, on the other hand, wood in the blade area has been preserved (Fig. 14b).

Optical microscopy has also facilitated the identification of metallic flakes, which are bound to attached impurities. These flakes are separated from the original surface by corrosion products and occur across the entire surface of the axe, both on the functional part and in the hafting area.

Analysis of the silver coatings

Coating of the axes with metal of different colour was observed with both electron and optical microscopy. After this discovery, all axes were first examined without magnification. It was confirmed that some specimens showed the residues of silvery layers even without magnification (Fig. 15). Then all axes were examined with an optical microscope and with SEM-EDS (Fig. 16). The SEM-EDS elements distribution map showed that these layers were made of silver (Fig. 17). To determine the character of the layers, X-Ray Diffraction (XRD) was applied, and it proved that the coating was Ag0, which means that the layers were elemental silver whereas the possibility of corrosion from the matrix could be excluded. Only where the element distribution maps showed scattered particles of silver on very crumbly layers was silver also present as a product of corrosion of the matrix that contained silver. Such layers have a very different character from the actual silver coating (Fig. 18). While the silver coating lies on the patina and clearly forms another layer, often polished, the corroded silver from the matrix is below the patina in the form of a crumbly uneven layer. Traces of polishing were clearly visible on the residues of the silver coating (Fig. 19). In this case, only non-conservated axes were considered relevant because silver is an extremely soft metal and polishing traces could also be created during conservation. This became evident on some conservated specimens, where the traces of mechanical cleaning were detected all over the silvery layers, in some cases even over the copper or bronze (Fig. 11).

Another result confirming that the silver coating observed on some axes cannot be caused by corrosion in an acidic environment is the low silver content detected in the matrix, in some cases even below the detection limit of the method used. The concentration of silver between 0.1 and 2.9 wt% is not sufficient to create the observed layers (see Giumlia-Mair 2020). Moreover, the appearance of working traces on the silver layer could be additional evidence of intentional coating with silver (La Niece 1993, 207).

The best-preserved examples came from Kukleny and Kunčice, as they were not submitted to conservation (see Schimerová et al. 2023). Here, the layers were preserved under calcified soil, which kept the otherwise very loose silver layers attached to the surface. In some cases, the layers of silver appear within the copper corrosion, which seems to have grown through the silver layers and attached them to the surface. These layers were preserved also on some conserved specimens (Fig. 20). In other cases, the copper corrosion completely destroyed the layers of silver, which helps to explain the poor preservation. So far, it has been impossible to measure the thickness of the layers in a precise way. We measured silver foils trapped between cracks in the patina only in one case. They measured approximately 1 µm (Fig. 21). However, with further analyses conducted with LIPS it became clear that the thickness of the layers is very uneven. The precise thickness has to be examined by future research as it could be important in determining the process of coating.

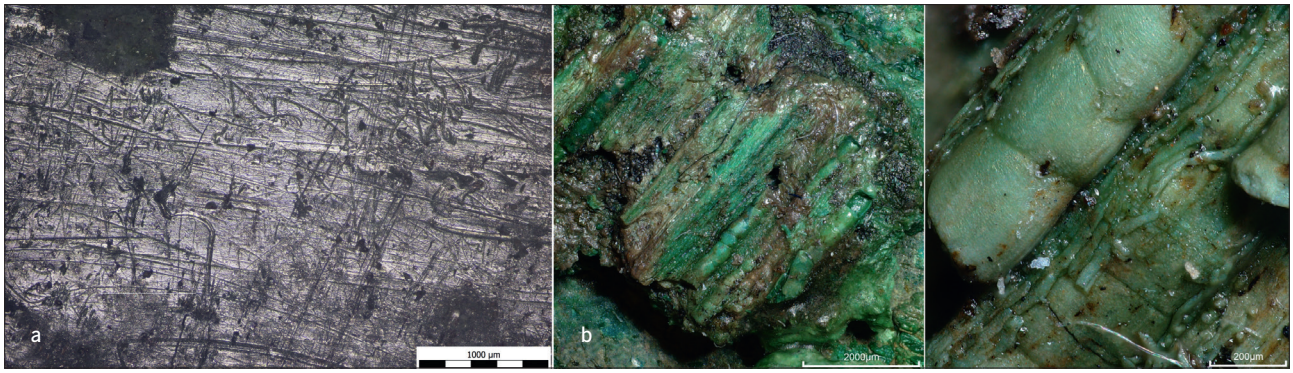

Fig. 14a–b Details of metal after contact with wood and organic residues. a Manipulative traces corresponding to contact with wood, Kukleny, Hradec Králové district, axe no. 79440; b Detail of wood preserved in the blade area, Mikulovice, Pardubice district, axe no. 4920.

Abb. 14a–b *Detailaufnahmen von Metall nach dem Kontakt mit Holz und mit organischen Überresten. a Nutzungsspuren, die zum Kontakt der Klinge mit Holz passen, Kukleny, Okr. Hradec Králové, Beil-Nr. 79440; b im Klingenbereich erhaltenes Holz, Mikulovice, Okr. Pardubice, Beil-Nr. 4920.*

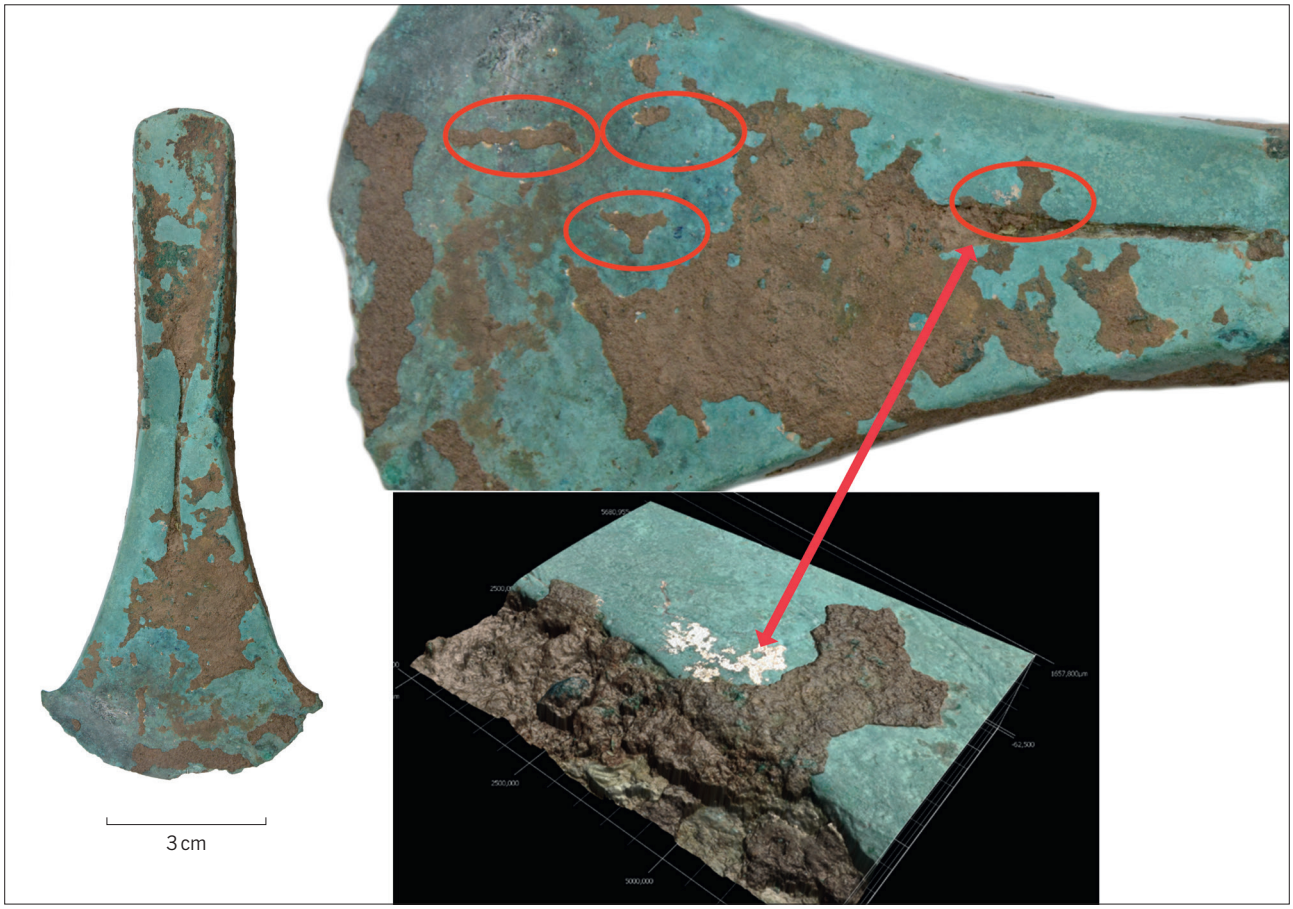

Fig. 15 Residues of silver coating without magnification and magnified detail on axe no. 79441 from Kukleny, Hradec Králové district.

Abb. 15 *Überreste der Silberbeschichtung ohne Vergrößerung und vergrößertes Detail auf Beil-Nr. 79441 aus Kukleny, Okr. Hradec Králové.*

If we take into account the frequency of silver coating with respect to the find context, from the 83 studied axes that came from hoards, 81 of them were available for examination. A silver coating was detected either optically or by optical microscopy on 38 of them. That represents nearly 47 % of the whole hoard assemblage. Using SEM, silver was detected on another 32 axes, but these results should be taken with caution, as no significant layer could be observed microscopically and the character of the silver particles was unclear. In contrast, the axes from graves and settlement contexts (three specimens in total) did not have any silver coating present on their surface. From 25 single finds, silver was positively detected only on three, which represents 12 %. In 12 more cases silver was detected only by SEM. Surprisingly, both of the axe-shaped hammers also bore traces of silver coating – in one case detected even macroscopically and in the other only with SEM. Adding everything together, silver coating was positively proven on 38 % of the entire studied assemblage. If we add also the more doubtful ones, the percentage would rise to 78 %.

Attempt at reconstructing an Early Bronze Age silvering technique

Today, various methods of silvering base metals are known: leaf silvering, fire silvering, galvanic silvering using electricity, and electroless silvering.

For the Early Bronze Age, only electroless silvering seems plausible, as the use of electric current can be excluded[8]. Leaf silvering would have required extremely thin silver leaves and an organic adhesive to attach them to the base metal. Such silvering would have been mechanically fragile due to insufficient adhesion. Fire silvering would have required the availability of mercury, which would have been detectable in analyses.

Chemical silvering (electroless plating) presupposes the availability of aqueous solutions of silver that can be applied to less noble metals. In this process, silver precipitates as an element on the metal surface, while the less noble metal (in this case, copper) passes into the solution. Many such methods are known today and are mostly based on silver nitrate or cyanide complexes. However, this would have meant that

8 The theories that have repeatedly surfaced since 1934, suggesting that there were already batteries generating electricity in ancient times and that the Parthians had executed galvanic gilding with them, have actually been debunked for years as a scientific legend (Eggert 1996).

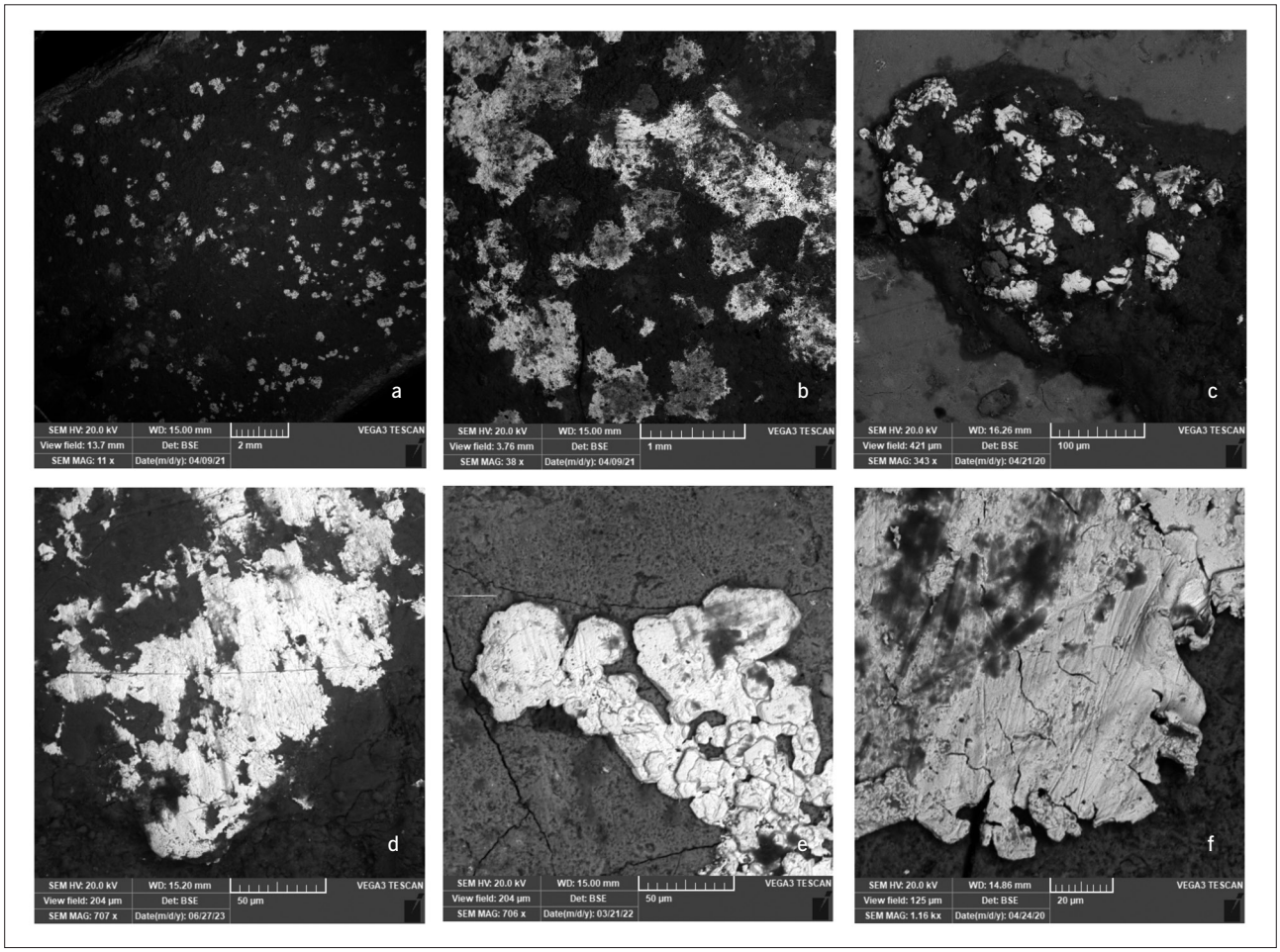

Fig. 16a–f Details of preserved silver coating from SEM, all samples are not conservated. a Jičíněves, Jičín district, axe no. A161; b Jičíněves axe no. A163; c Kunčice, Hradec Králové district, axe no. 82455; d Žáravice, Pardubice district, axe no. 12065; e Kukleny, Hradec Králové district, axe no. 79482; f Kukleny axe no. 79441.

Abb. 16a–f *Details von erhaltener Silberbeschichtung unter dem Rasterelektronenmikroskop; unkonservierte Proben. a Jičíněves, Okr. Jičín, Beil-Nr. A161; b Jičíněves, Beil-Nr. A163; c Kunčice, Okr. Hradec Králové, Beil-Nr. 82455; d Žáravice, Okr. Pardubice, Beil-Nr. 12065; e Kukleny, Okr. Hradec Králové, Beil-Nr. 79482; f Kukleny Beil-Nr. 79441.*

nitric acid or even alkali cyanides were available during the Bronze Age. Nitric acid (aqua fortis) only appeared in alchemical laboratories at the end of the 15th century, and cyanides emerged in the 19th century. These substances were unknown during the Bronze Age. So how could silver be brought into an aqueous solution? Two quite old,

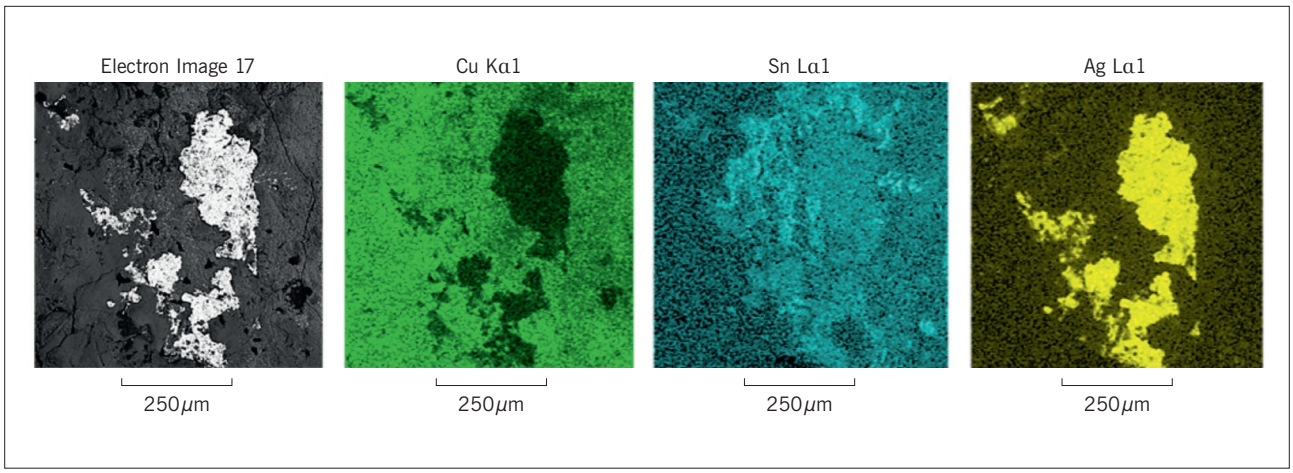

Fig. 17 The map of elements distribution in the place of the silver coating residues of axe no. 79456 from Kukleny, Hradec Králové district (SEM).

Abb. 17 *Elementverteilung an der Stelle mit Überresten von Silberbeschichtung von Beil-Nr. 79456 aus Kukleny, Okr. Hradec Králové (REM).*

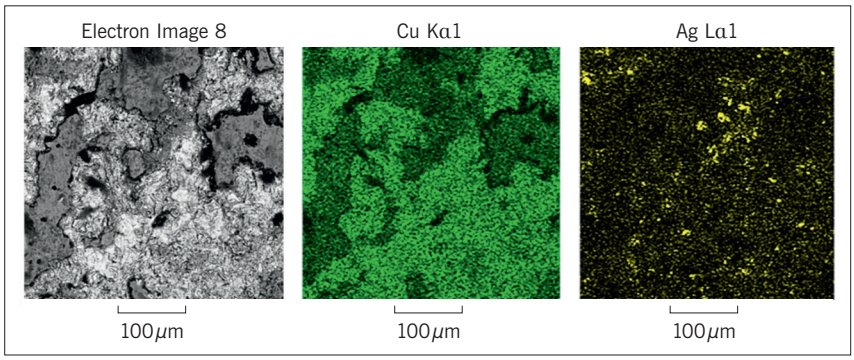

Fig. 18 The map of elements distribution in the silver-rich places on the surface of axe no. 79476 from Kukleny, Hradec Králové district (SEM).

Abb. 18 *Elementverteilung an den silberreichen Stellen auf der Oberfläche von Beil-Nr. 79476 aus Kukleny, Okr. Hradec Králové (REM).*

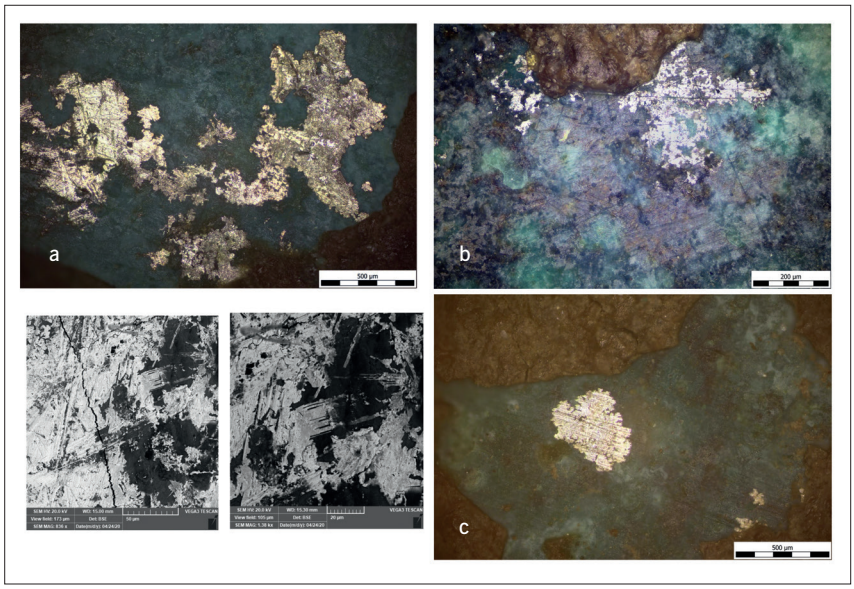

Fig. 19a–c Silver coating layers with traces of polishing/wear traces on non-conservated axes. a Kukleny, Hradec Králové district, axe no. 79441; b Kukleny axe no. 79441 from (SEM); c Kukleny axe no. 79462.

Abb. 19a–c *Silberbeschichtung mit Polier-/Abnutzungspuren auf unkonservierten Beilen. a Kukleny, Beil-Nr. 79441; b Kukleny, Okr. Hradec Králové Beil-Nr. 79441 (REM); c Kukleny, Beil-Nr. 79462.*

preindustrial formulations for silvering can be found in A. Helmreich's *Kunstbüchlein* (Little Art Book), printed in Eisleben in 1563 (Helmreich 1563); the book's author was a mathematician and court clerk in Halle. On the second-to-last page of the work, which otherwise deals with the production of inks and pigments for manuscript illumination, there are two recipes for silvering copper. The first recipe uses (freshly precipitated) silver (or horn silver: which is not entirely clear), salt (natrium chloride), and cream of tartar. The paste is to be rubbed on the object to be silvered with the finger. The second recipe is somewhat unclear, using sal ammoniac (ammonium chloride), »galmei« (a zinc ore, not specified), cream of tartar, alum, silver powder, vinegar, and freshly deposited fine silver. The ingredients are briefly heated and applied.

The mechanism inherent in both recipes is that silver chloride (horn silver), initially formed by the action of acids (acetic acid, cream of tartar, alum) and the entry of oxygen, turns into soluble Ag-chloro complexes in the presence of an excess of chloride ions (from the abundantly added table salt). In both cases, there are aqueously dissolved silver ions. These ions deposit on the copper surface according to the principle of ›electroless plating‹, where the less noble copper passes into the solution, and the elemental silver is deposited. Similar formulations are essentially still used today, and corresponding commercial products are sold as ›rub-on silvering‹. Clear formulations can be found in practical textbooks from the 19th century. One frequently mentioned instruction is the »rub-on silvering according to Langbein« (Buchner 1891, 86) using 10 g of silver chloride, 20 g of cream of tartar, 20 g of table salt, and adding water to the consistency of dough. The paste is then applied to the workpiece.

Our experiments (Tab. 2) primarily tested the combination of silver chloride/cream of tartar/table salt, as well as silver chloride/table salt/acetic acid. All variations work and form a more or less dense, closed silver coating that can be polished to a high gloss with an agate afterwards (Fig. 22). The practical execution is surprisingly simple: Just a few drops of a silvering paste made of silver chloride, table salt, and organic acid are rubbed on the base metal surface with a brush or fingertip, and, within a few minutes, a bronze/copper metal is brilliantly silvered (Fig. 23).

Another ›chemical‹ likely used in the Early Bronze Age was fermented urine, possibly for patinating bronze surfaces (Berger 2012). Silver chloride is also soluble in weak ammoniacal solutions, forming silver diamine complexes. We conducted experiments in this direction as well, using ammonium carbonate instead of fermented urine. Although it is relatively easy to bring silver chloride into solution in this way, when these solutions are applied to the copper surface, only a colloidal, black precipitate of silver forms, and no usable metallic coating is produced. Thus, the system of

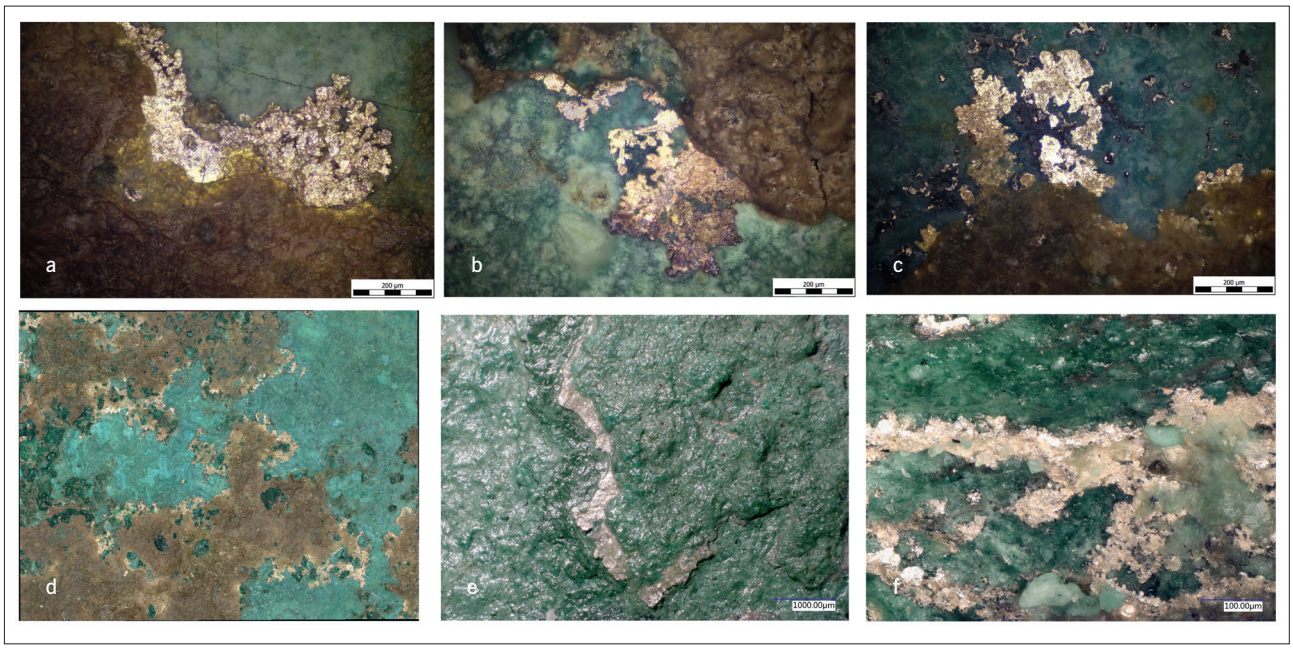

Fig. 20a–f Silver coating layers attached to the surface with calcified soil residues or copper corrosion. a Kukleny axe no. 79483; b Kukleny axe no. 79461; c Kukleny axe no. 79455; d Kukleny axe no. 79455; e Těchlovice axe no. 74800; f Těchlovice axe no. 74800.

Abb. 20a–f *Mit verkalkten Erdresten oder Kupferkorrosion an der Oberfläche anhaftende Silberbeschichtung. a Kukleny, Beil-Nr. 79483; b Kukleny, Beil-Nr. 79461; c Kukleny, Beil-Nr. 79455; d Kukleny, Beil-Nr. 79455; e Těchlovice, Beil-Nr. 74800; f Těchlovice, Beil-Nr. 74800.*

silver chloride/table salt in a slightly acidic medium (vinegar, fruit acids) works best and fastest. The question arises: Did the Únětice artisans in Bohemia have access to silver chloride or horn silver at all?

There is initially the theoretical possibility that artificially produced silver chloride from imported silver could have been used. The process involves a method similar to the so-called ›cementation‹ for purifying gold. Silver-rich gold (or pure silver) is heated with ceramic flour and table salt, producing silver chloride, which is absorbed by the ceramic flour and could then have been used for silvering. However, this technique was unknown in the Early Bronze Age (Wunderlich et al. 2014).

More likely, in the spirit of Occam's razor, it seems that there was no need to search long for silver chloride in Bohemia. It was simply lying around in some places in the form of the so-called ›horn ore‹. This ore is pure silver chloride. The term »horn ore« first appears in the Italian publication by M. A. Della Fratta Montalbano entitled *Pratica Minerale* (Montalbano 1678). There it says: »Ottima ancora è quella di color del corno, che chiamano i Tedeschi Hornerz, della qual fe ne caua nella Valle loachimia di Kutembergh«[9].

Although the Jáchymov (Joachimsthal) mine was only opened after 1516, it can be assumed that outcropping silver ores in the form of horn silver were known and available before this time, even if not used for silver production

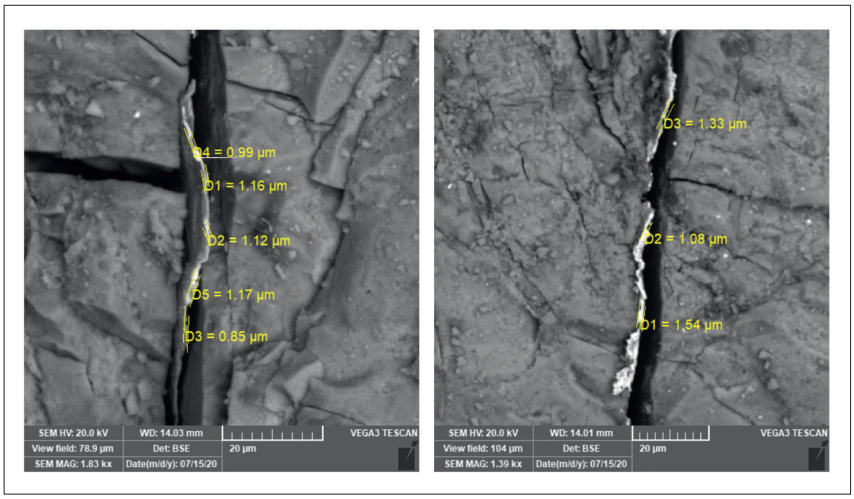

Fig. 21 Part of detached silver coating trapped between cracks in the copper corrosion layers (SEM).

Abb. 21 *Teil der abgelösten Silberbeschichtung in Rissen zwischen den Schichten der Kupferkorrosion (REM).*

9 Montalbano 1678, 96; »Excellent is also that horn-colored ore, which the Germans call ›Hornerz,‹ and is extracted in the Joachimsthal Valley near Kutná Hora«.

Experiments on »Bronze Age« Silvering
1. **Rub-in silvering, simple, with horn silver Silver chloride** 1 part Table salt 5 parts Mix with a little water. Rub on bare copper with a glass rod under light pressure, polishing at the same time. Result: It works, but there are slight defects. Copper chloride seems to form, which, due to the high pH, does not dissolve properly.
2. **Rub-in silvering** (»Anreibeversilberung nach Langbein« Buchner 1891, 86) Formulation as above, addition of ›cream of tartar‹ (potassium hydrogen tartrate) 100 mg silver chloride 200 mg cream of tartar 200 mg sodium chloride. Mix with a little water to form a paste, apply with a cloth. Works very well and, above all, very quickly. The paste can also be picked up with the finger and spread on the surface. Within a few minutes, a well-cleaned copper or bronze hatchet can be silvered.
3. **Silvering also succeeds if diluted acetic acid (5 %)** is used instead of cream of tartar.
4. **Silvering using ammonium carbonate and silver chloride** 100 mg silver chloride is rubbed into 100 mg ammonium carbonate in about 1 ml of water and applied to the copper surface. The solution turns slowly black (probably colloidal silver), but no closed silver surface is formed.

Tab. 2 Recipes of possible silver coating methods verified experimentally.

Tab. 2 *Rezepte denkbarer Silberbeschichtungsmethoden, experimentell überprüft.*

(Lommer 1776, 26). C. H. Lommer reports that horn silver is mainly found »in upper, insignificant depths«, meaning at or near the Earth's surface. He states that horn silver appeared »three to four ells under the turf and surface of the earth« during the reopening of a shaft in the »Gotthelf Schallerer Berggebäude«[10]. Other locations mentioned for horn silver are Marienberg, Schneeberg, Annaberg, all Erzgebirgskreis district, and Jáchymov, Karlovy Vary district, in Bohemia. In light of this, it seems entirely probable that Únětice metalworkers had access to silver chloride in the form of naturally occurring horn silver, even without the need for extensive silver mining. Additionally, the required quantities were small. Only a few milligrams of horn silver were needed to completely silver an axe.

Internal structure of the axes

The study of the internal structure of axes was conducted with X-ray and tomographic scanning. While axes from copper and its alloys appear to be well cast, their inner structure often shows frequent casting defects. The casting defects were originated during the cooling of the melt in the casting molds. The most common were closed cavities in the alloy. This type of casting defect is caused by the changing solubility of gases in the melt during cooling and the insufficient deaerating of casting molds (Atkins 2006).

Other casting defects were open shrinkages which were observed in the butt of some axes. The open shrinkages were formed in the places where the melt was solidified last. The formation of open shrinkages was caused by the insufficient height of the risers and by the improper location of the gating system in the casting molds used. The location of these shrinkages in the butt of the axes suggests casting into probably closed molds that were in perpendicular position (with the edge at the bottom of the mold). The inner shrinkages and the shrinkage porosity (Fig. 24) were also observed in some axes. The uneven cooling of the bronze melt in the casting molds, the improper location of the gating system, and the improper construction of the casting molds used were the main reasons for these defects. Very often, significant damages of the blades by corrosion were observed.

Discussion

The majority of axes from eastern Bohemia come from only one hoard containing 57 artefacts from the total of 111 axes. Only one axe comes from a grave, two fragments come from stratified settlement features, and the remaining 25 come from unspecified contexts. One of the two axe-shaped hammers comes from a hoard and the other was found in the 19th century under unknown circumstances. This proves that, as in other groups of the Únětice Culture, axes are most frequent in hoards. The phenomenon has been interpreted in many different ways, yet it shows a clear inclination towards accumulating axes in hoards rather than displaying them in graves as a symbol of individual status (see Meller 2017). The one axe from a grave is also consistent with this theory. The fragments from settlement contexts are very important because they indicate that metal axes were used alongside stone axes, which were still frequent at Early Bronze Age settlements. The low frequency in settlement contexts could be connected to the reuse of the metal after the axe was damaged and not suitable for use anymore. Many axes might had been reutilised, and their original number must have been much higher. Four of the hoards were stored in a ceramic vessel, which is a common feature of hoards in Central Germany. In this context, the hoard from Dermsdorf is very unique, as it was found during the excavation of the site. Here, 98 axes and two unfinished halberd cast blanks were buried by the side of a long house (Küßner/Wechler 2019; Meller 2019a).

10 Johanngeorgenstadt, Erzgebirgskreis district, today Saxony, on the border with the Czech Republic.

Fig. 22 Experiments of silver coating with silver chloride, sodium chloride, and cream of tartar.

Abb. 22 *Versuche zur Silberbeschichtung mit Silberchlorid, Natriumchlorid und Weinstein.*

Results of the elemental composition of the axes show that the majority of them were made from bronze with different amounts of tin. Some specimens were made from fahlore copper (Junk et al. 2011; Lutz/Pernicka 2013). The majority of them also showed the intentional addition of tin.

The comparison between the elemental compositon of axes from hoards from eastern Bohemia and Central Germany shows that, in the latter area, axes were made predominantly from copper (see Meller 2019; Meller 2019a). By contrast, in eastern Bohemia the axes were made mainly from bronze.

Fig. 23a–c Results of silver coating experiments. a silver chloride; b sodium chloride; c cream of tartar.

Abb. 23a–c *Ergebnisse der Silberbeschichtungsversuche. a Silberchlorid; b Natriumchlorid; c Weinstein.*

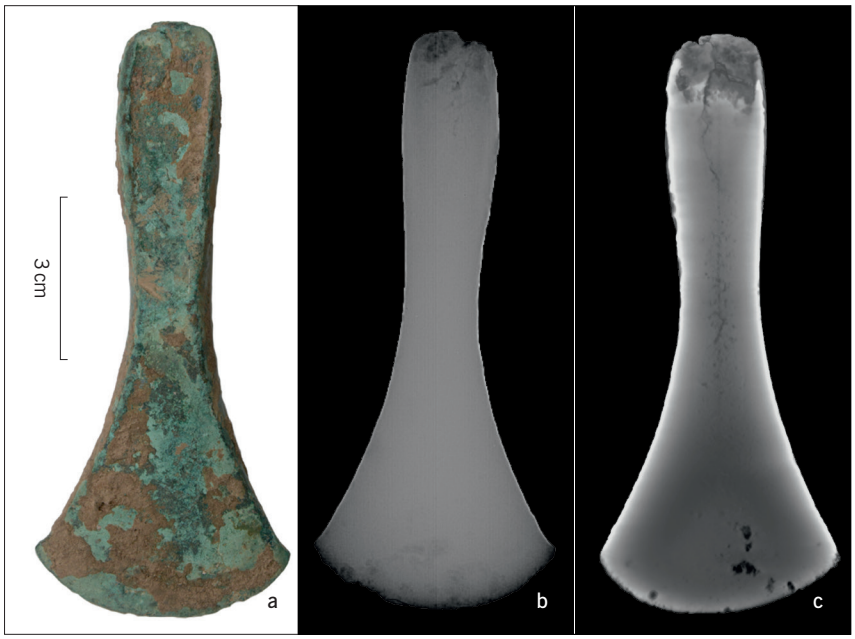

Fig. 24a–c Documentation of an open shrinkage with photography (a), X-ray (b; 200 kV, 180 uA) and CT (c).

Abb. 24a–c *Dokumentation einer offenen Schrumpfung mittels Fotografie (a), Röntgen (b; 200 kV, 180 uA) und Computertomografie (c).*

Based on use-wear analysis, we can argue that the axes primarily served for woodworking, while we lack enough data to conclusively identify traces from combat activities. Surprisingly, wear traces also appear on axes with a surface application of precious metal. Regarding the silver coating of the entire surface, the question arises whether it occurred before or after the axe was hafted. Since silver residues are present on all parts of axes, including the hafted sections, it is challenging to draw a definitive conclusion. The evidence supports both possibilities Conducting experiments with siver-coated axes could help determine the stability of the silver layer and possibly clarify the timeline of these modifications.

Current experiments are focused on axes as tools. The axe is a versatile object that can be used both as a tool and as a weapon, as evidenced by, among other things, iconographic sources (e.g., Horn 2023). There are quite a few specimens with typical signs of wood processing, including tree-felling (Dolfini/Crellin 2016; Dolfini et al. 2023). Without sufficient experimental data, traces of combat that would prove the use of axes as weapons are still difficult to confirm.

The definitive confirmation of silver coating could radically change the current view on Early Bronze Age metallurgy. Aside from the Iberian Peninsula, where silver was used in large scale to manufacture jewellery or the silver rivets of daggers (Lull et al. 2014; Delgado-Raack et al. 2016), in Central Europe silver had been absent since the Late Neolithic, where it occasionally appears in Bell Beaker contexts (Moucha 1971; Peška 2016). But thereafter, suddenly, silver seems not to have been used throughout the entire Bronze Age. There is only one recent example of artefacts made from silver, namely, the four silver rings from an Early Bronze Age cemetery in Erding, Bavaria (Biermeier et al. 2022). Our research on axes from eastern Bohemia shows that silver was present in a different way – in the form of coating. Coating with another metal – gold, electrum, or, in rare cases, tin – has been observed already[11]. From the Czech Republic, examples of silver coating have been published, such as a bronze ornaments from Moravská Nová Ves, Břeclav district, and from Mikulovice (Ptáčková/Ustohal 1996; Ernée et al. 2020). The hoard found in Sýčina, Mladá Boleslav district, is probably the best-preserved example with the thickest and most extent layer of silver present on the surface (Šteffl et al. 2017). There are many questions connected to this phenomenon, the first being the reason for such practice. So far, we have not been able to propose any functional or technological advantage that would change the quality of the particular tool/weapon. The most likely explanation is for aesthetic or symbolic reasons. There are strong indications that the colour of the final product was important and that Early Bronze Age metallurgists were intentionally altering the colour through the casting process. H. Meller proposed this theory when considering the weapons of the Únětice Culture in Central Germany. His studies concluded that colour mattered to such degree that it distinguished different ranks in the organised military society (Meller 2019; Meller 2019a). The composition of the metal is one way to influence the final colour of the artefact. In the most simple way, copper artefacts have a reddish colour, but by adding tin it is possible to alter the colour towards a more golden, and by arsenic towards a more silvery hue (e.g., Mödlinger et al. 2017; Radivojević et al. 2018). Coating metal with a

11 E.g., Berger et al. 2010; Berger et al. 2019; Rožnovský 2015; Kinnes et al. 1979; Meeks 1986.

layer of another metal shows another step that could allow even more possibilities involving not only the change of colour but perhaps also decorative features. All this is, however, hard to prove because the corrosion processes damage the coated surface to a level where its original extent is impossible to reconstruct. From the entire collection, the coating was present on almost 38 % of the axes[12]. The remains of the silver layers were observed on the entire surface, including the parts that were hafted. Further research will be necessary in order to ascertain the specific technology or technologies used for the coating. Moreover, even though we were able to confirm, that the layers were not caused by corrosion from the matrix, more experiments are necessary to exclude any possibility of the silvery layers to be result of a reaction with the environment of any kind. However, we can see a certain preference for silvery-coloured metal artefacts in Bohemia, as has already been observed by D. Berger (2018). In this context, it is also interesting to mention the hoard from Dolany, which, in addition to an axe probably coated with silver, also contained bracelets with a shiny, greyish silvery surface that strongly resemble similar bracelets from Thuringia (where, according to other artefacts found with them, a Bohemian origin is also considered). With their high content of tin (up to 20 %), the silvery surface of these Thuringian bracelets was most probably caused by inverse segregation (so-called tin sweat), and, although the intentionality of this phenomenon could not be confirmed, as it is a result of casting process, it neverthless indicates the preference for a silvery surface in Bohemia (Berger 2018).

Another interesting question concerns the geographical and chronological occurrence of silver coating. So far, it has been observed only on Early Bronze Age artefacts from Bohemia and on one artefact from Moravia (Ptáčková/Ustohal 1996; Ernée 2020; Šteffl et al. 2017)[13]. An interesting observation has been provided by the investigation of the cemetery at Mikulovice. In graves 12 and 13, two women were buried who, among other artefacts, had stone tools with traces of gold and silver. The woman buried in grave 13 also had jewellery that was coated with silver (Ernée et al. 2020). These two women were presumably working with precious metals, and, since we have no silver artefacts from that period, they may also have been specialised in coating with silver. The cemetery of Mikulovice also lies less than 30 km away from the largest hoard of axes at Kukleny.

The inner structure of the axes could clarify the actual process of casting. No stone moulds have been found in Central Europe, which means they were made from non-durable materials such as clay or sand and are therefore very hard – or, in case of sand moulds, nearly impossible – to detect. The position of casting defects such as open shrinkages, which were present specifically on the butts of axes, show that this part of an axe solidified last. This tells us that one casting method could employ a closed mould in a perpendicular position with the edge at the bottom and the butt at the top. Although such casting defects were quite frequent, there were definitely axes that were cast quite well. However, due to their similar shape, we can assume that this method was quite frequent. Another option could be casting into flat open moulds, which would be harder to prove as most of the irregularities could have been smoothened by forging and hammering.

Conclusion

The coating of copper and bronze artefacts with silver in the Únětice Culture has so far been observed only in Bohemia. Our investigation has proven that this phenomenon may be more common than previously assumed, since 38 % of the studied axes from eastern Bohemia were definitely covered with layers of silver. Poor preservation probably explains why many cases remained undetected until now. Corrosion processes of copper can destroy the coating layers, leading to their detachment and eventually to their complete loss.

The observed layers were very thin and could have been obtained with a method of electroless plating. Using chemical methods for coating with precious metals requires deep knowledge and skill. The exact technique needs to be further tested experimentally to determine the potential thickness and durability during use, but our experimental work has proven that the effect is very prominent. The coating of copper and bronze axes with such a thin silver layer can only imply an intention to change the visual appearance of the artefacts. In Central Germany, a similar optical effect seems to have been achieved by selecting specific metal compositions to enhance the outer appearance of the axes. In this sense, the findings from eastern Bohemia contribute to the hypothesis that colour was important among metal artefacts. The proposed coating technique changes the colour so radically that, after polishing the surface, it resembles pure silver. Such an effect would be very hard to achieve by mixing alloys.

While the stability of the layer needs to be tested experimentally, its reapplication is so fast and simple that it would probably not be considered a demanding and time-consuming activity. In principle, all the required ingredients (silver chloride, salt, acid) could have been obtained from local sources. More complex is the technical knowledge applied, indicating that metal axes were a rare and highly valued commodity. It seems that most of them ended up being deposited in hoards, whereas the axes from settlement and funeral contexts seem to lack silver coating. Further investigations, especially on non-conservated axes, are necessary in order to determine whether coating with silver was specific to Bohemia or was also known in other regions of the Únětice Culture. Experiments also need to be carried out in order to exclude confusion with other processes and to sort the different appearences of silver on the artefact surfaces.

12 If the ones with silver residues observed only by SEM are also included, the percentage rises to 87 %. But in these cases we cannot exclude that some small silver particles could occur naturally through corrosion processes.

13 It was presumably observed once in Sweden, but in this case the authors themselves doubt whether the silver is a result of a corrosion process or an intentional coating (Brink et al. 2016).

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Archaeometallurgical investigations into the production of Early and Middle Bronze Age flanged axes in Central Germany

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Zusammenfassung

Archäometallurgische Untersuchungen zur Herstellung früh- und mittelbronzezeitlicher Randleistenbeile in Mitteldeutschland

Im Rahmen der vorliegenden Untersuchungen wurden früh- und mittelbronzezeitliche Beile mithilfe modernster Methoden hinsichtlich ihrer Zusammensetzung und der Verarbeitungsschritte untersucht. Anhand metallografischer Schliffe wurde das Gefüge der Beile umfassend charakterisiert. Dabei konnte ermittelt werden, wie die Beile vom Gießen bis zum fertigen Produkt verarbeitet wurden. Im Gusszustand zeigen sich in den Beilen zahlreiche Gussfehler. Erst eine wiederholte Bearbeitung aus Schmieden und Glühen verleiht dem Werkstoff die notwendige mechanische Festigkeit, wie die Untersuchungen belegen konnten. Die praktikable Verfahrensweise ist dabei immer abhängig von der Zusammensetzung des Materials. Aus den Erkenntnissen der Studie leitet sich ab, dass die Hersteller dieser Beile über ein fundiertes, tiefgreifendes und über lange Zeit erworbenes Verständnis der Materialverarbeitung verfügt haben müssen.

Schlagwörter Archäometallurgie, Bronzezeit, Randleistenbeil, Metallografie, Schmieden

Summary

As part of the present investigations, Early and Middle Bronze Age copper-based axes were examined with regard to their composition and processing stages using state-of-the-art methods. The microstructure of the axes was comprehensively characterised using metallographic sections. This made it possible to determine how the objects were processed, from casting to the finished product. Numerous casting defects can be seen in the hatchets in the as-cast state. Only a repetition of forging, annealing, and cold working gives the material the necessary mechanical strength, as the investigations were able to prove. The practicable procedure always depends on the composition of the material. The findings of the study indicate that the smiths of these axes must have had a profound understanding of material processing, acquired over a long period of time.

Keywords Archaeometallurgy, Bronze Age, flanged axe, metallography, forging

Introduction

The production of tools from metals is a significant step in human history. The examination of such objects provides profound insights into the knowledge of material processing and skills in the respective epoch and region. Bronze Age axes are thus revealing artefacts, as their usability requires certain properties – in this case, the combination of hardness and ductility. These functional properties result from a certain elemental composition and a processing method adapted to it.

The chemical composition and the origin of the alloying elements used in many Bronze Age copper-based axes have been well researched[1]. Older finds (c. 2000–1775 BC) in particular show that the composition of the metal is unfavourable for achieving the desired functional properties in an as-cast state. In this respect, they differ significantly from modern bronze materials. The targeted alloying of copper with tin increases the strength and hardness of the material by forming a solid solution lattice. A higher tin content within the alloy results in a greater strength and hardness of the material. Modern bronzes, such as CuSn10, contain so much tin (10 mass % Sn in CuSn10) that even the cast state is usable due to its elevated hardness. Axes from the Early and Middle Bronze Age rarely have a sufficiently high tin content for the tools to be ready for use in the as-cast state. Adequate further processing of the materials is therefore essential.

Both the production and processing of metallic materials determine the microstructural composition and thus the properties of the material. An in-depth analysis of the material provides information about its processing history from the casting to the finished tool (Scott 1991, 7–8 Fig. 11–12)[2].

1 Cf. on axes from Central Germany, e.g., Pernicka 2010, 723–725; Lockhoff et al. 2019; Schwarz 2019; see also Berger et al. in this volume.

2 On the metallography of Central European axes see Kienlin 2008; Kienlin 2010.

Fig. 1 Overview of the 10 objects P1–P10.

Abb. 1 *Übersichtsaufnahmen der 10 Untersuchungsobjekte P1–P10.*

Ten flanged axes from the Early and Middle Bronze Age were materialographically analysed. The focus was placed on the elaboration of the cutting edge, on the one hand, and on the manufacturing of the flanges, on the other. In this article, the results for two of the ten axes are presented.

Objects under investigation

The following table and the corresponding illustration show the axes provided for examination by the State Museum of Prehistory Saxony-Anhalt. The objects originate from the Central German region and range in date from the Early Bronze Age (AK3, according to R. Schwarz (2021), or Bz A1b[/A2a]) to the Middle Bronze Age (Bz C1–D). These are flanged axes of different types (Saxonian type, Bühl type, Mägerkingen type); only one object belongs to the class of Palstave of North German type (Tab. 1; Fig. 1).

The overall project looks at all ten axes. For the sake of clarity, this article will initially concentrate on the results of the analyses of samples P2 and P3. These both come from the Halle-Kanena III hoard find (von Brunn 1959, 59; Verweis Beitrag 23). They differ minimally in their chemical composition (Tab. 2) but can both be categorised as arsenic copper objects[3]. Such arsenic copper objects differ significantly from modern bronze materials in terms of their chemical composition and thus their properties.

3 Otto/Witter 1952, 30–31; 33–34; Krause 2003, 132–133; 189–190; Kienlin 2008, 121; Lockhoff et al. 2019, 135–139; Schwarz 2019, 114; see also Berger et al. in this volume.

Sample designation	Inventory number	Location	Type	Dating (according to Schwarz 2021)	Literature
P1	HK 13:2448	Beichlingen, Sömmerda district	Mägerkingen type	Bz B1, 1550–1450 BC	Fröhlich 1983, 175 Nr. 397 (»Gegend von Großneuhausen«)
P2	HK 34:305l, 30	Halle-Kanena III	Saxonian type	AK 3, 1975–1775 BC	von Brunn 1959, 59
P3	HK 34:305l, 34				
P4	HK 37:18l, 194	Dieskau III, Saalekreis district	Saxonian type	AK 3, 1975–1775 BC	von Brunn 1959, 56
P5	HK 37:18l, 211				
P6	HK 37:18l, 285				
P7	HK 41:493	Braunsbedra-Benndorf, Saalekreis district	Bühl type	AK 5–Bz B1, 1625–1450 BC	Fröhlich 1983, 150 Nr. 168
P8	HK 5225	Gröbers-Bennewitz I, Saalekreis district	Saxonian type	AK 4, 1775–1625 BC	von Brunn 1959, 57f.
P9	HK 5237				
P10	HK 2306	area of Halberstadt, Harz district	North German Palstave	Bz C1–D 1450–1250 BC	Fröhlich 1983, 178f. Nr. 425

Tab. 1 Overview of the Objects under investigation.

***Tab. 1** Übersicht über die Untersuchungsobjekte.*

sample	content in wt%											
	Fe	Ni	Cu	Zn	As	Se	Ag	Sn	Sb	Au	Pb	Bi
P2	< 0.02	< 0.01	97	< 0.20	1.14	< 0.005	1.21	< 0.005	0.90	< 0.01	< 0.01	0.02
P3	< 0.02	0.30	97	< 0.20	0.37	< 0.005	1.06	0.092	0.86	< 0.01	< 0.01	< 0.01

Tab. 2 Chemical composition of P2 and P3 determined by means of X-ray fluorescence analysis. The analyses were carried out by E. Pernicka, CEZA Mannheim.

***Tab. 2** Chemische Zusammensetzung von P2 und P3 mittels Röntgenfluoreszenzanalyse ermittelt. Die Analysen wurden von E. Pernicka, CEZA Mannheim durchgeführt.*

Investigations

Preparation

The samples were first documented photographically, and the cutting positions for the microsections were defined. For each axe, a longitudinal section was made with a view of the cutting edge and a cross-section with a view of the flanges. The preparation was minimally invasive so that the axes could be reassembled and restored after the analyses.

The separating cuts were carried out using wire erosion. The cutting width here was around 0.1 mm. Figure 2 shows the two objects after cutting.

The preparation route was based on preparation recipes from comparable studies and adapted to the task of minimally invasive ablation (Petzow 2006; Kienlin et al. 2006). The separated specimens were embedded in the next step. A cold embedding agent that is soluble in acetone was used for this purpose. This makes it possible to remove the samples without leaving any residue after the analyses.

Fig. 2a–b Axes after wire eroding. a P2; b P3.

***Abb. 2a–b** Äxte nach dem Trennen mittels Drahterosion. a P2; b P3.*

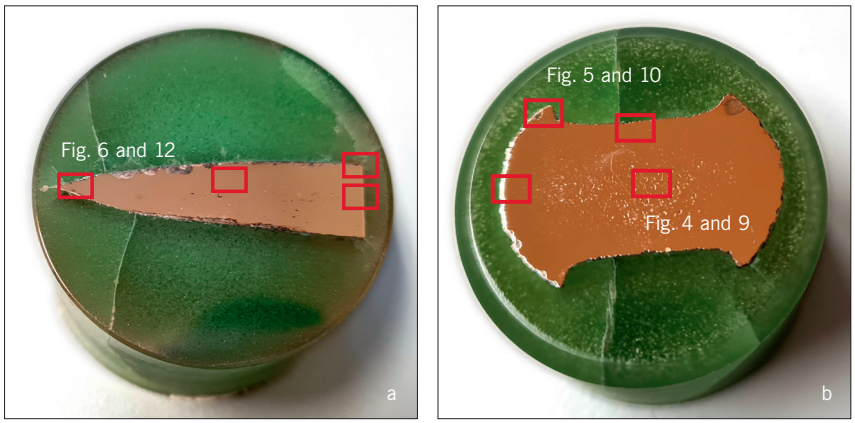


Fig. 3a–b Specimens (red boxes) after metallographic preparation. a Longitudinal section with a view of the cutting edge; b cross-section with a view of the flanges.

Abb. 3a–b *Proben (rote Kästchen) nach der metallografischen Präparation. a Längsschliff mit Blick auf die Schneide; b Querschliff mit Blick auf die Randleisten.*

The embedded samples were then ground manually on a water-cooled disc grinding machine on silicon carbide paper. Careful and cautious grinding by hand makes it possible to keep the grinding times and thus the removal for each sample as short as possible but as long as necessary. The samples were then polished in several stages with diamond suspension on a semi-automatic machine. To remove deformation layers, the samples were etched between the diamond polishing stages. An etching polish made of colloidal silica (pH ≈ 9.5 and grain size 0.06 μm) and hydrogen peroxide was used as the final polishing stage to produce a scratch- and deformation-free surface. The samples were contrasted with hydrochloric acid ferric chloride solution (grain boundary etching, etchant 1) and Klemm II etchant (colour etching, etchant 2). The exact parameters of the preparation are listed in Tab. 3 below. The total amount of material removed by cutting and preparation is approximately 0.5 mm. Figure 3 shows an example of the two microsections polished in this way.

step	description	parameters
grinding	1.: P180	SiC-paper
	2.: P320	H_2O-cooling
	3.: P600	30–45 s
	4.: P800	10–15 N
	5.: P1200	manually
	6.: P2500	300 U/min
	7.: P4000	
polishing	6 μm diamondsuspension, on soft wool cloth	4 min, 20 N, 150 U/min
	etching with etchant 1	3 s
	3 μm diamondsuspension, on soft wool cloth	7 min, 15 N, 150 U/min
	etching with etchant 1	3 s
	1 μm diamondsuspension, on short flocked, soft synthetic cloth	10 min, 15 N, 150 U/min
	etching with etchant 1	3 s
	0.06 μm colloidal silica + H_2O_2 (32 %) 5:1, on soft synthetic cloth	5 min, 15 N, 150 U/min
etchant 1	100 ml C_2H_5OH + 20 ml HCL (32 %) + 5 g $FeCl_3$	5 s
etchant 2	100 ml saturated $Na_2S_2O_3$-solution + 5 g $K_2S_2O_5$	60–120 s

Tab. 3 Metallographic sample preparation of the embedded sample sections.

Schritt	Beschreibung	Parameter
Schleifen	1. Stufe: P180	SiC-Papier
	2. Stufe: P320	H_2O-gekühlt
	3. Stufe: P600	30–45 s
	4. Stufe: P800	10–15 N
	5. Stufe: P1200	manuell
	6. Stufe: P2500	300 U/min
	7. Stufe: P4000	
Polieren	6 μm Diamantsuspension, auf SIGMA	4 min, 20 N, 150 U/min
	Zwischenätzen Ätzung 1	3 s
	3 μm Diamantsuspension, auf SIGMA	7 min, 15 N, 150 U/min
	Zwischenätzen Ätzung 1	3 s
	1 μm Diamantsuspension, auf ZETA	10 min, 15 N, 150 U/min
	Zwischenätzen Ätzung 1	3 s
	0,06 μm kolloidales Silizium-dioxid + H_2O_2 (32 %) 5:1, auf ZETA	5 min, 15 N, 150 U/min
Ätzung 1	100 ml C_2H_5OH + 20 ml HCL (32 %) + 5 g $FeCl_3$	5 s
Ätzung 2	100 ml gesättigte $Na_2S_2O_3$-Lösung + 5 g $K_2S_2O_5$	60–120 s

Tab. 3 *Metallografische Präparation der eingebetteten Bronzeproben.*

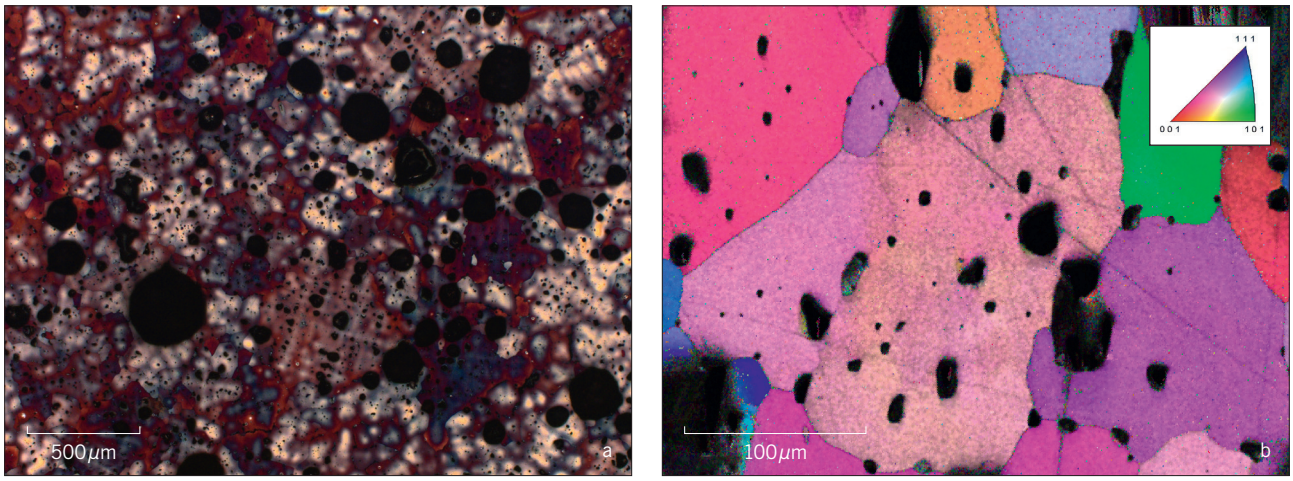


Fig. 4a–b P2. Cross-section, pore- and voud-laden microstructure. a Colour etching shows the casting dendrites; b IPF colour-coded and IQ grey-scaled EBSD map shows coarse grained and deformation-free microstructure.

Abb. 4a–b *P2. Querschliff, poren- und lunkerbehaftetes Grundgefüge. a Die Farbätzung zeigt deutlich Gussdendriten; b die IPF-farbcodierte und IQ-grauwertskalierte EBSD-Karte zeigt grobkörnige und verformungsfreie Mikrostruktur.*

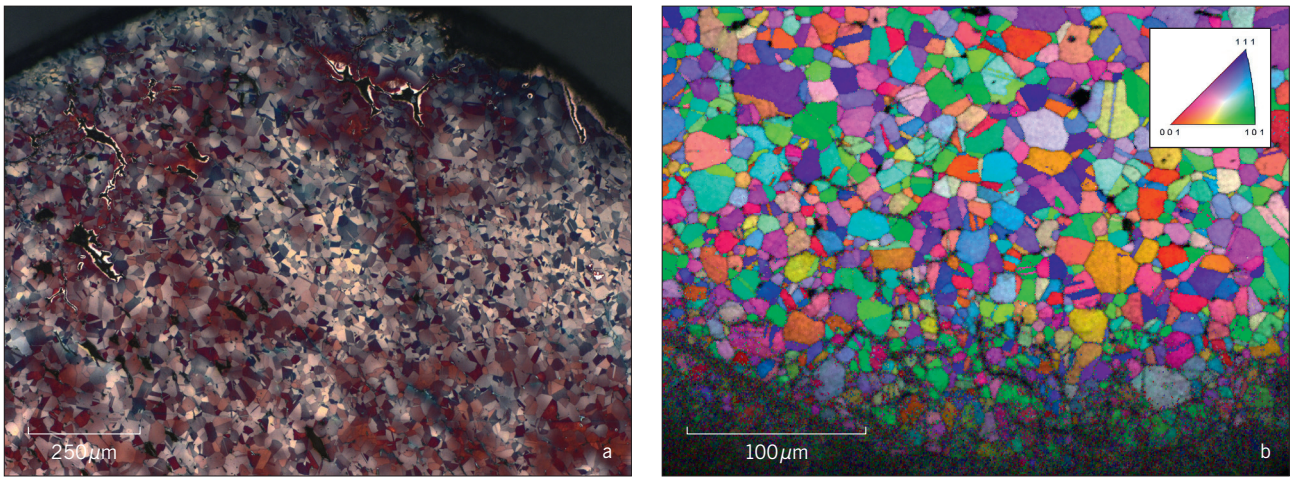


Fig. 5a–b P2. Cross-section, tip of the flange, fine-grained, recrystallised structure. a Colour-etched with casting segregations still visible; b IPF colour-coded and IQ grey-scaled EBSD map shows a deformation-free microstructure with annealing twins.

Abb. 5a–b *P2. Querschliff, Spitze der Randleiste, feinkörniges, rekristallisiertes Gefüge. a Farbätzung Gussseigerungen noch erkennbar; b die IPF-farbcodierte und IQ-grauwertskalierte EBSD-Karte zeigt eine verformungsfreie Mikrostruktur mit Glühzwillingen.*

Microscopy and analytics

The metallographic sections were microscopically investigated and analysed in the areas shown in Fig. 3. Light microscopy was used to generate images in the polished, grain-boundary etched (etchant 1), and colour-etched (etchant 2) state. Here, the focus was placed on the characteristics of the microstructure.

The samples were used in their polished state for the electron microscopic analyses. To ensure sufficient electrical conductivity of the embedded sample, it was sputtered with gold. Images were taken in secondary electron contrast (SE) and backscatter electron contrast (BSE). Furthermore, investigations were carried out using energy dispersive X-ray spectroscopy (EDS) and electron backscatter diffraction (EBSD). The EBSD data is presented as colour-coded inverse pole figure (IPF) and grey-scale image quality (IQ) maps. The coloured representation shows the spatial orientation of the individual grains. The grey value within the coloured tone in these maps is an indication of the quality of the measurement signal.

The electron microscopic analyses provide in-depth information on the microstructure and chemical element distribution of the samples examined.

Sample 2

The core of P2 has a coarse-grained, dendritic cast structure. The large number of casting pores and voids is striking (Fig. 4). The microstructure is different in the area of the flange. Here, too, casting defects can still be seen, but these are deformed into an oval shape. The microstructure is finer in this area, and annealing twins can be found. In the colour-etched images, stripes of different colours can be seen, which follow the course of the flange (Fig. 5).

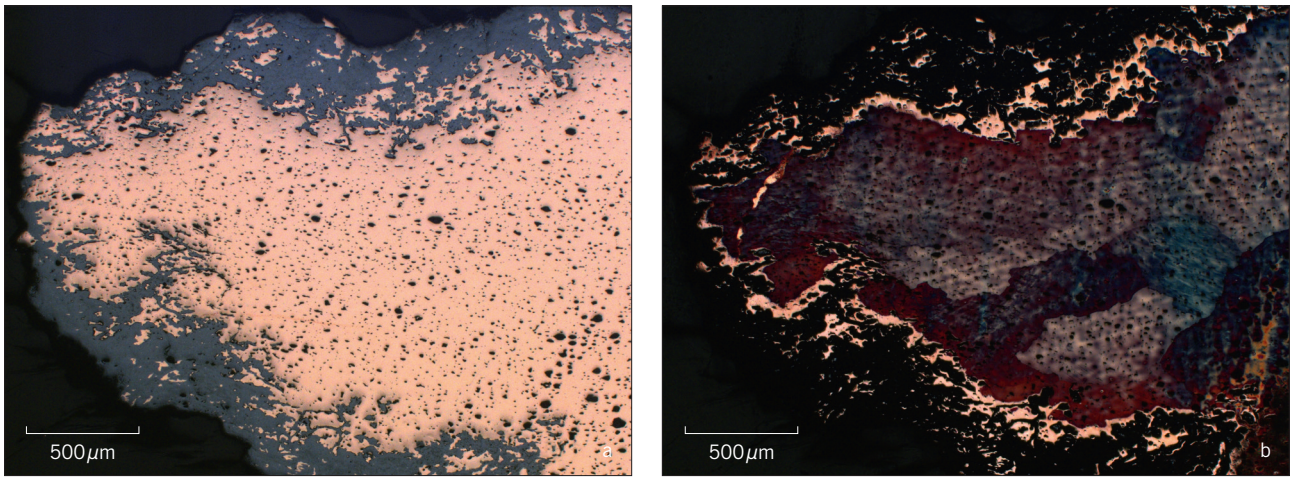


Fig. 6a–b P2. longitudinal section, tip of the blade is still in the cast state. a In the polished state; b colour etching.

Abb. 6a–b *P2. Längsschliff, die Klingenspitze liegt noch im Gusszustand vor. a Im polierten Zustand; b Farbätzung.*

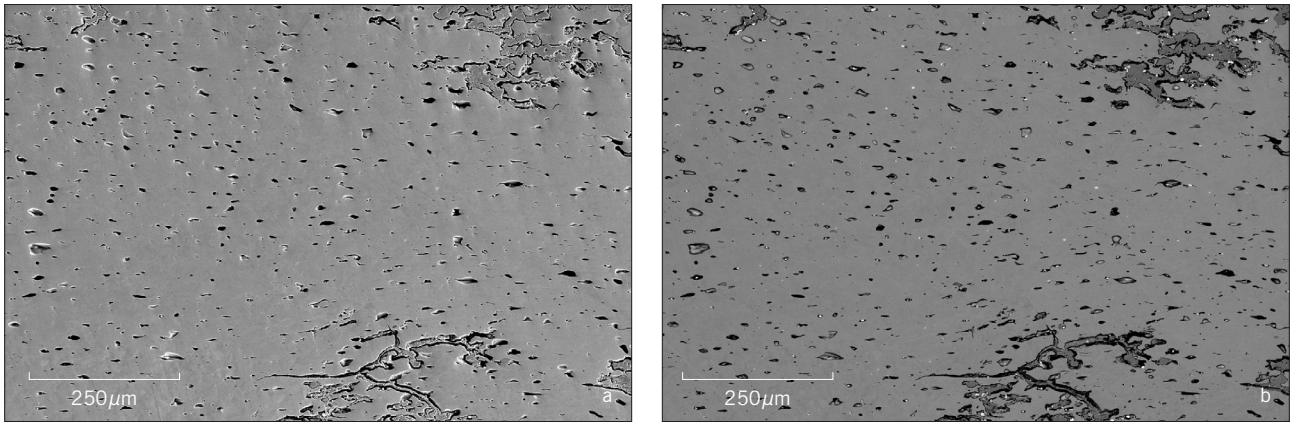


Fig. 7a–b P2. Longitudinal section, tip of the blade, slightly moulded casting blowholes. a REM-SE; b REM-BSE.

Abb. 7a–b *P2. Längsschliff der Klingenspitze, mit leicht eingeformten Gusslunkern. a REM-SE; b REM-BSE.*

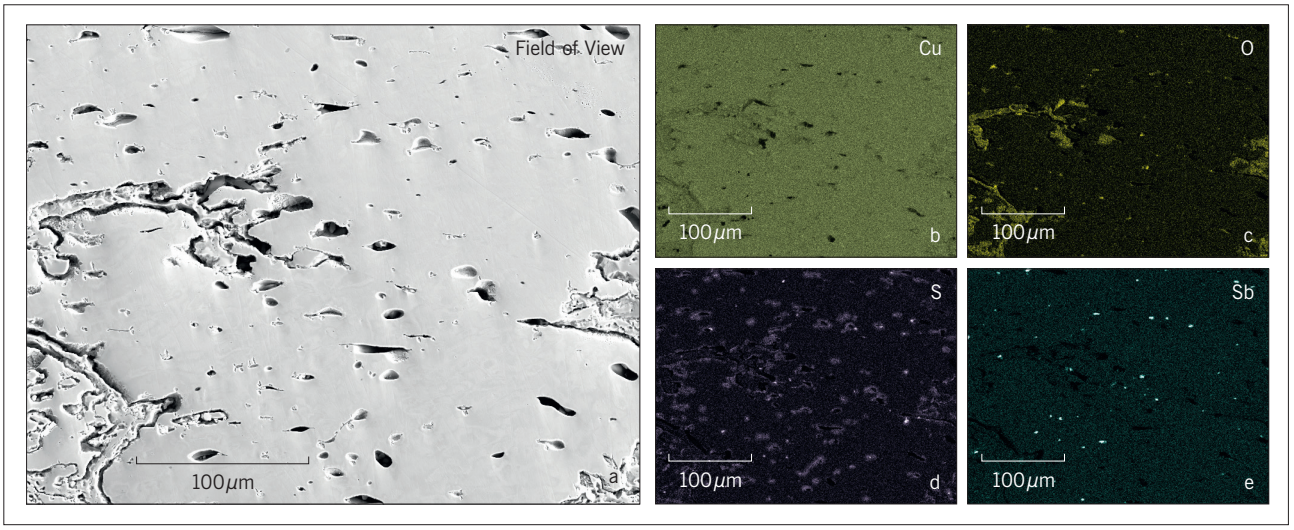


Fig. 8a–e P2. EDS mapping in the area of the blade tip. a Overview image of the scan area in SE mode; b copper; c oxygen; d sulphur; e antimony.

Abb. 8a–e *P2. EDS-Mapping im Bereich der Klingenspitze. a Übersichtsaufnahme des Scan-Bereichs im SE-Modus; b Kupfer; c Sauerstoff; d Schwefel; e Antimon.*

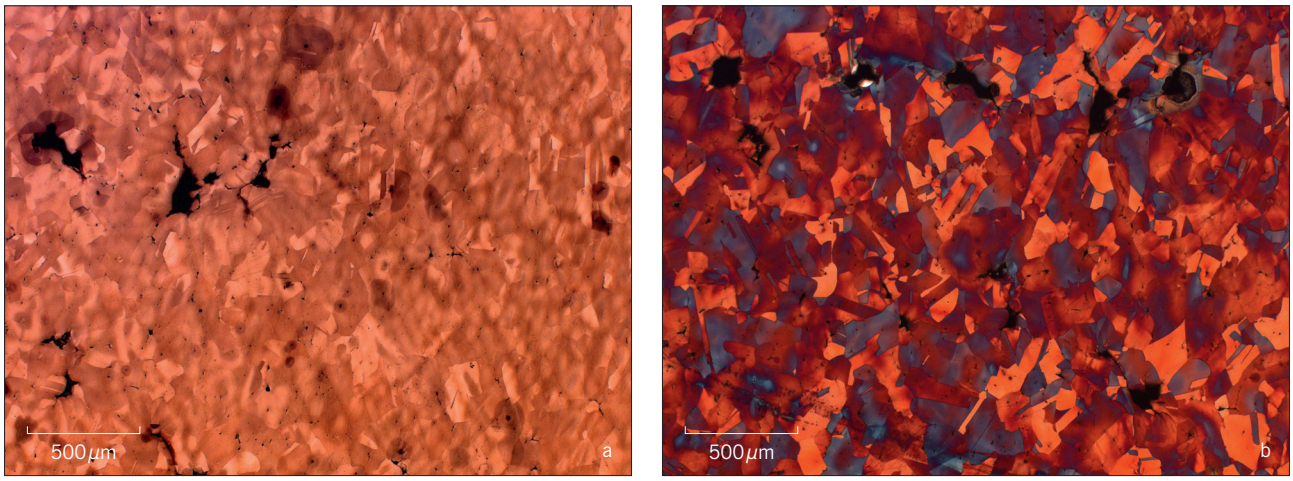


Fig. 9a–b P3. Cross-section recrystallised microstructure with partially formed casting blowholes. a Grain boundary etching; b colour etching.

Abb. 9a–b *P3. Querschliff mit rekristallisiertem Grundgefüge mit teilweise eingeformten Gusslunkern. a Korngrenzenätzung; b Farbätzung.*

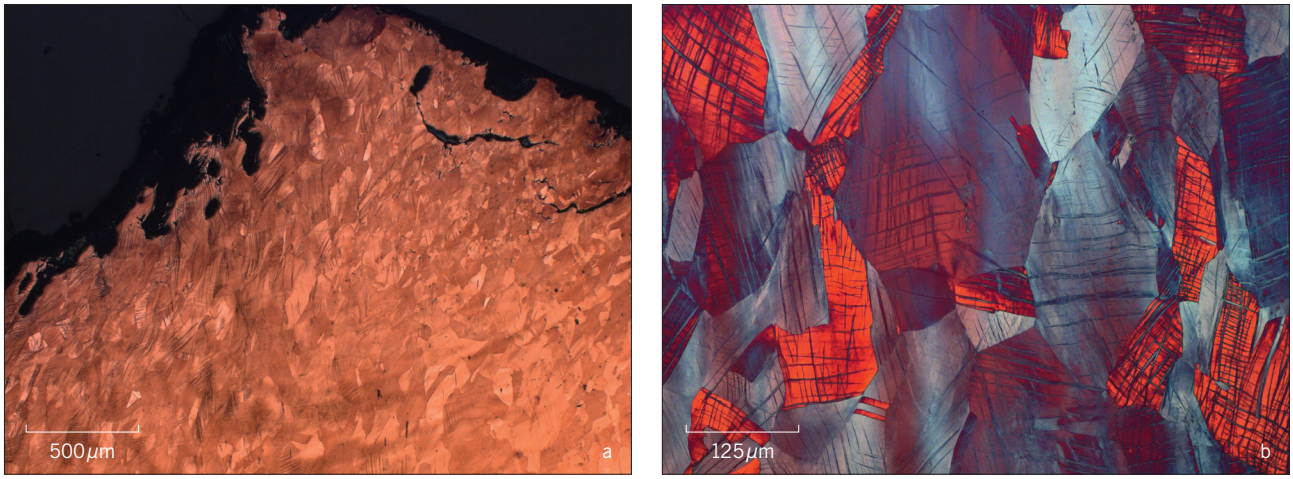


Fig. 10a–b P3. Cross-section tip of the flange, recrystallised and highly deformed structure with slip bands. a Grain boundary etching; b colour etching.

Abb. 10a–b *P3. Querschliff von der Spitze der Randleiste, rekristallisiertes und stark deformiertes Gefüge mit Gleitbändern. a Korngrenzenätzung; b Farbätzung.*

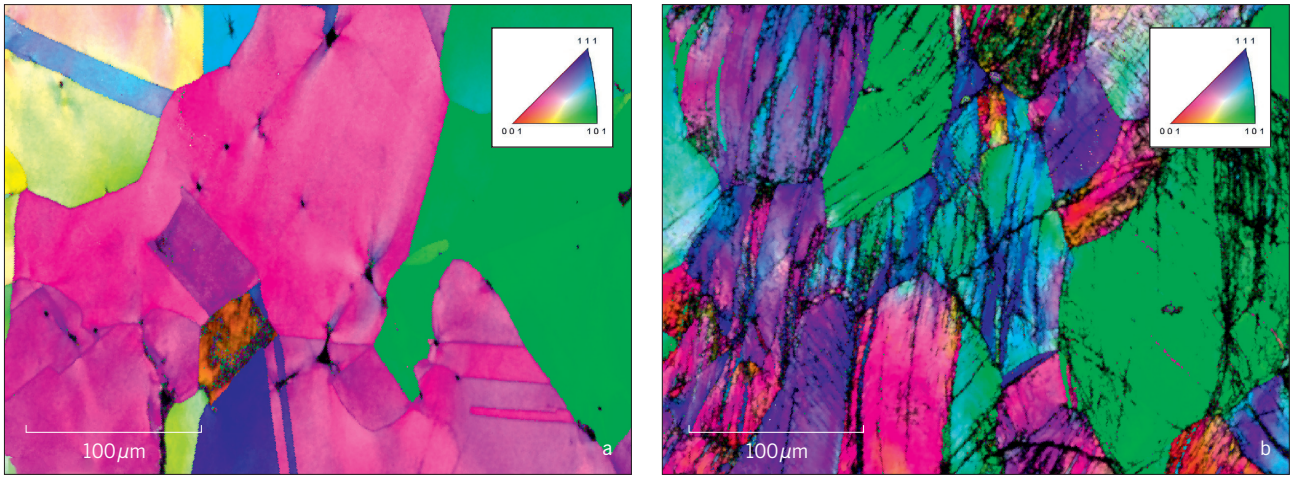


Fig. 11a–b P3. Cross-section, IPF colour-coded and IQ gray-scale EBSD maps; a Coarse-grained, homogeneous, deformation-free microstructure in the centre of the sample; b coarse-grained, heavily deformed microstructure interspersed with slip bands in the area of the flange.

Abb. 11a–b *P3. Querschliff, IPF-farbcodierte und IQ-grauwertskalierte EBSD-Karten. a Grobkörniges, homogenes, verformungsfreies Grundgefüge; b grobkörnige, stark deformierte und von Gleitbändern durchzogene Mikrostruktur im Bereich der Randleiste.*

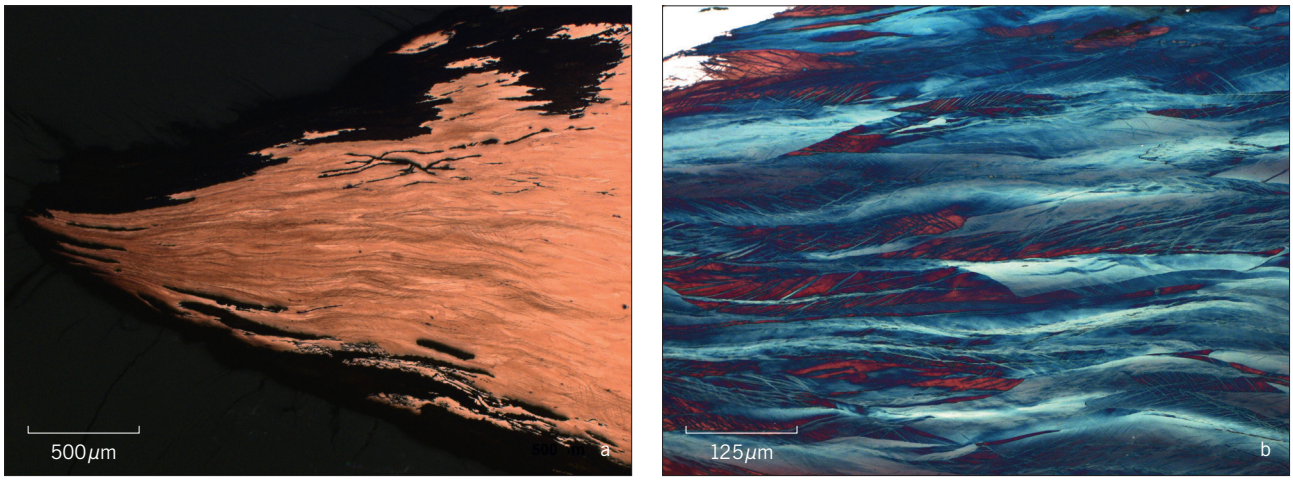


Fig. 12a–b P3. Longitudinal section of blade tip, recrystallised and subsequently highly deformed structure. a Grain boundary etching; b colour etching.

Abb. 12a–b *P3. Längsschliff der Klingenspitze, rekristallisiertes und anschließend hochgradig deformiertes Gefüge. a Korngrenzenätzung; b Farbätzung.*

The large proportion of casting defects in this sample indicates poor casting quality. The core of this axe shows a deformation-free microstructure typical of castings that have not been affected by hammering. The situation is different in the area of the flange. There is a recrystallised, homogeneous, and fine-grained microstructure with oval-shaped casting defects. The edge was therefore first deformed mechanically and then heat-treated (Scott 1991, 7–8 Fig. 11–12). During the heat treatment, the deformation in the microstructure was reduced, and recrystallisation and the formation of annealing twins occurred (Fig. 5a). However, the temperature was not high enough that the segregations from the casting were dissolved, since these are still visible as a colour gradient in the colour-etched state.

The illustrations of the longitudinal section (Fig. 6), in the area of the cutting edge, show a similar microstructure to the core area of the cross-section. A dendritic microstructure typical of castings with clear casting defects is present across the entire longitudinal section. Slightly deformed cast dendrites are only recognisable in the tip of the blade. The blade was therefore only minimally mechanically worked at the tip.

The electron micrographs in SE and BSE mode as well as the EBSD-analysis confirm and deepen the findings from the light microscopy. The images show many casting defects in the tip area, some of which are oval in shape. In BSE mode, isolated bright-coloured, and therefore heavier, elemental precipitates can be identified in the material, as well as darker, and therefore lighter, areas in the outer part. The bright-coloured precipitates could be identified as antimony oxides using EDS (Fig. 7–8). These originate from the manufacturing process. The darker areas at the edge are copper oxides, which were formed due to corrosion during burial.

Sample 3

The images of P3 show a recrystallised and coarse-grained microstructure with little casting defects in the core. Both etchings resulted in a blotchy appearance. The existing casting blowholes are deformed in this area (Fig. 9). This sample also shows a recrystallised grain in the area of the flanges. In contrast to the core structure, however, the grains here are elongated and interspersed with slip bands. Existing casting defects are completely closed (Fig. 10).

The resulting microstructure indicates an intensive mechanical processing of the entire material volume. The recrystallised microstructure was created during the subsequent heat treatment. However, the heat treatment was not so intensive that the material was homogenised, which is why the segregations from the casting are still visible as blotchy artefacts in the etched samples.

The microstructure of the flanges indicates a multi-stage manufacturing process. First, the flange was forged into shape and then heat-treated to restore the material's malleability. This resulted in recrystallisation of the previously deformed material. After recrystallisation, the flange was cold-forged again. The slip bands formed and the grains were deformed elongated (Scott 1991, 7–8 Fig. 11–12).

The IPF colour-coded and IQ grey-scale EBSD maps of the core and the tip of the edge clearly show the above-named differences and confirm what the light microscopy has shown (Fig. 11). The core has a coarse-grained, homogeneous and undeformed microstructure. In the area of the flange, a clear colour gradient and thin, darker slip-lines can be seen within the individual grains. The colour gradient indicates grain rotation and therefore deformation within the single grains. This pronounced grain rotation, as well as the presence of several slip-systems per grain, indicate a pronounced mechanical processing during the last processing stage, which, however, only took place along the flange.

A similar picture can be seen in the area of the tip of the blade (Fig. 12). Here, too, the microstructure is recrystallised and heavily deformed. The grains are even more deformed here than in the area of the flange, which indicates an even higher degree of deformation in the final manufacturing stage (cf. Northover 1989, 113 Fig. 13.2).

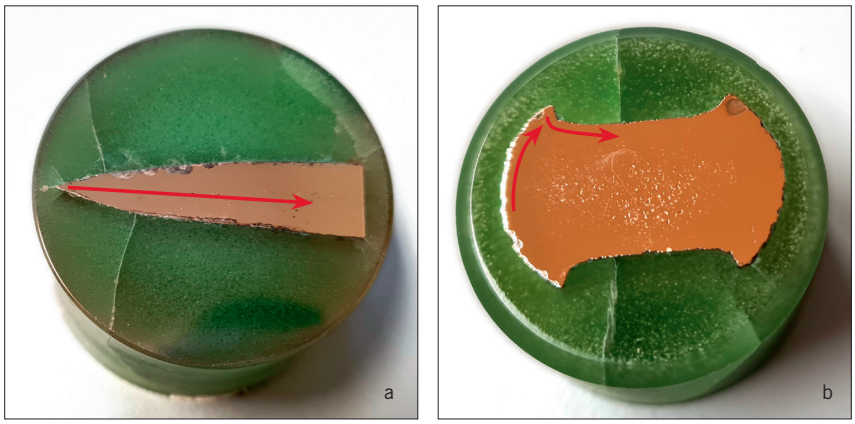


Fig. 13a–b Measuring profile. a In longitudinal section from the tip of the blade along the centre axis; b in cross-section from the flank of the flange over its tip to the upper part of the middle ridge.

Abb. 13a–b *Messprofile. a Im Längsschliff von der Spitze der Klinge entlang der Mittelachse; b im Querschliff von der Flanke der Randleiste über deren Spitze zum oberen Teil des mittleren Stegs.*

Hardness testing

Following the microscopic analyses, the mechanical properties of the two objects were determined. The hardness and strength of a material is decisive for its use as an axe. To determine the local hardness distribution, microhardness measurements (Vickers method, HV0.1) were carried out on the metallographic sections. The advantage of microhardness testing is that measurements can be taken very locally. Furthermore, the zone of plastic deformation around the indentation is relatively small (diameter of indents between 30 and 70 μm), so that only minimal preparation would be required for any subsequent examinations.

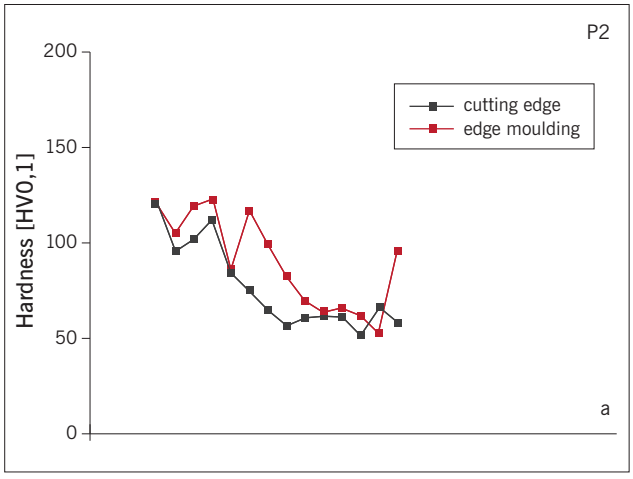
For the longitudinal section, a microhardness curve was measured from the tip of the blade along the longitudinal axis to the core of the material (Fig. 13). For the cross-section, measurements were taken along the contour from the flank of the flange, over the tip of the flange, to the upper part of the middle ridge.

The results of the microhardness testing are shown in Fig. 14. The hardness measurements on P2 show that the blade tip has the highest hardness (125 HV0.1). Along the longitudinal axis, the hardness decreases relatively constantly to a level of c. 55 HV0.1. The flank and tip of the flange are similar to the hardness of the blade tip, whereas the upper part of the middle ridge is almost as soft as the core structure.

The results of sample P3 tend to show a similar hardness curve to those of sample P2. However, a higher strength level is present here. At the tip of the blade, the maximum hardness is just under 190 HV0.1 and then drops constantly to c. 100 HV0.1. The difference between the two axes can be explained by their different microstructures. The final cold-forming in sample 3 led to work hardening in the material. This increases the hardness and strength compared to a non-deformed microstructure (Gottstein 2014, 254–255).

Summary and outlook

As part of the overall project, ten flanged axes from the Early and Middle Bronze Age were archaeometallurgically examined. The axes come from the Central German region and from various hoard finds. These objects were first separated using wire erosion, then embedded, metallographically prepared, and analysed. The mechanical properties were determined by means of microhardness measurements. The entire procedure was coordinated in such a way that a maximum of c. 500 μm of material was lost through cutting and preparation. This allows the objects to be restored.



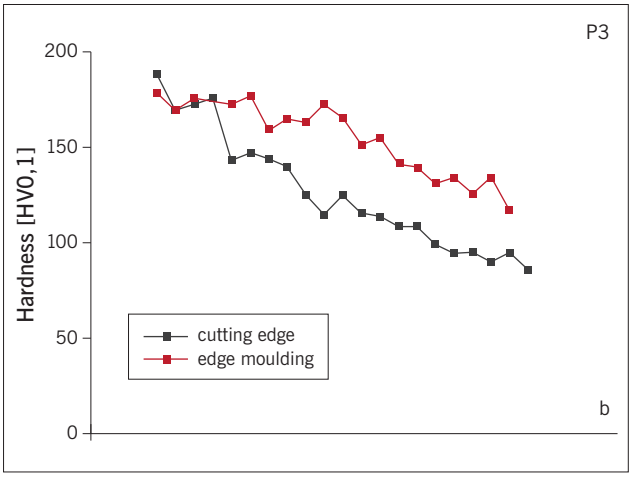


Fig. 14a–b Results of the microhardness testing. a P2; b P3.

Abb. 14a–b *Ergebnisse der Mikrohärteprüfung. a P2; b P3.*

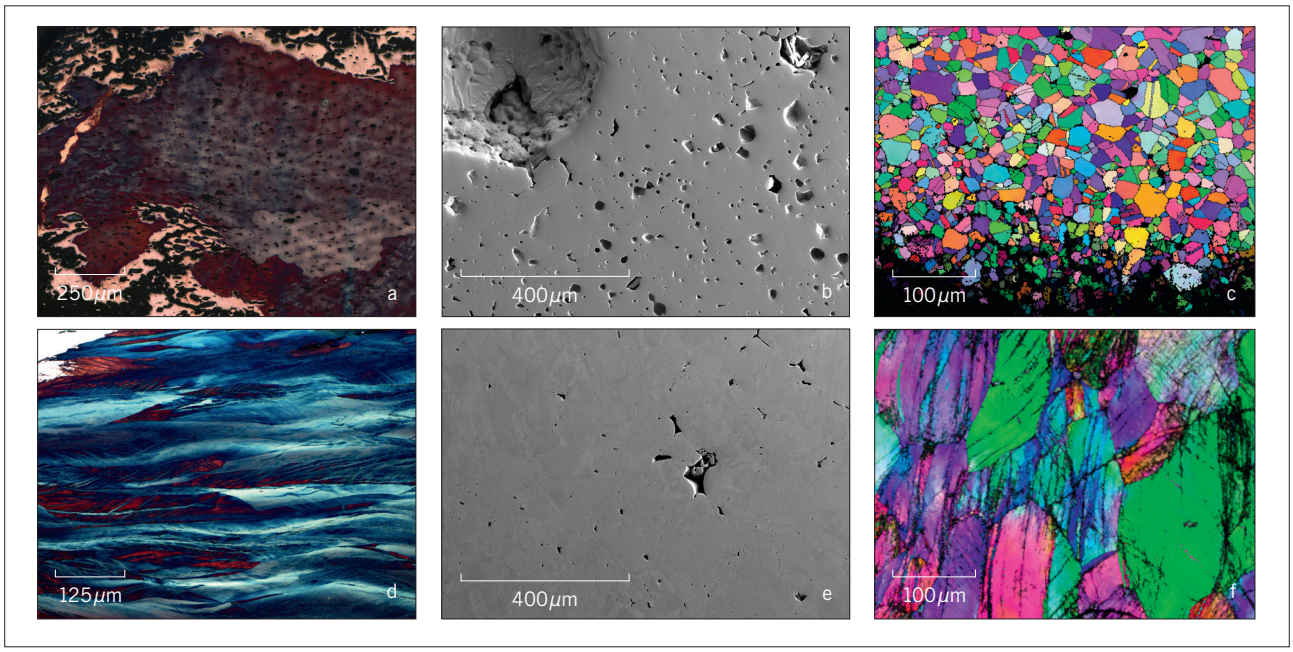


Fig. 15a–f Comparison of the two objects, top row P2, bottom row P3. Although both objects come from the same hoard find, they differ significantly in their microstructure and thus their properties.

Abb. 15a–f *Gegenüberstellung der beiden Objekte, obere Zeile P2, untere Zeile P3. Obwohl beide Objekte aus demselben Hortfund stammen, unterscheiden sie sich deutlich in der Mikrostruktur und damit in den Eigenschaften.*

In this study, the examination results of two of the ten axes were compared in more detail. The two axes, P2 and P3, come from the Halle-Kanena III hoard find (AK 3; 1975–1775 BC) and belong to the flanged axes of the Saxonian type. However, the investigations have shown that the two axes differ significantly in their microstructure and thus their properties.

The microsections of sample P2 show a porous and blowhole-laden material with a dendritic microstructure typical of castings. Only the outermost tip of the blade and the flanges appear to be mechanically processed. The microstructure in the area of the rim of this sample suggests that a multi-stage process has taken place here. First, the rim was forged, and then the material was heat-treated. Recrystallisation occurred in this area, resulting in a fine-grained, homogeneous, and deformation-free microstructure.

Sample P3 is clearly different. The material here is significantly more compact and denser. The sections show fewer blowholes and almost no pores. A relatively coarse-grained and recrystallised microstructure is present over the entire examined sample surface. This recrystallised grain was subsequently reshaped in the area of the flanges and the tip of the blade. This resulted in the slip bands and the elongated alignment of the grains in this area.

The investigations show that not only the blades but also the flanges of samples P2 and P3 were forged. This stands in contrast to current research opinion, which assumes that the Saxonian flanged axes were cast in two-part moulds and, with the exception of the blades, were only slightly reworked (Kienlin 2008, 173; 185)[4].

The different microstructures result in varying usage properties. For example, both axes have a higher hardness in the area of the blade tip and the flanges than in the core structure. However, the maximum hardness of sample P2 is only 125 HV0.1, whereas the blade tip of sample P3 is 190 HV0.1. Cold forging in the final processing stage significantly increased the mechanical properties of sample P3. Accordingly, this axe was better suited for wood-working, butchering, or as a weapon, in contrast to axe P2. Whether this difference was caused by a less experienced craftsman making P2 or whether this object was not yet finished remains an open question.

In the further course of the project, the analysis of the microstructural properties and their characteristics is to be completed. Based on the overall results, and with the help of replica tests, a non-destructive testing routine using eddy current testing is to be developed for such bronze objects. In future, this will be used to determine similarities and differences, as shown here, both non-destructively and on a larger sample scale. Initial promising investigations have already made it possible to correlate the existing microstructures and properties with the eddy current signals.

4 The two samples of flanges examined by Kienlin from pieces similar to the Saxonian axes come from axes with a high tin content of just under 7 and 11 % respectively, which may well have been processed in a different way to non-alloyed axes (Kienlin 2008, 174).

Abbreviations

BSE backscatter electrons – Rückstreuelektronen
EBSD electron backscatter diffraction – Elektronenrückstreubeugung
EDS energy dispersive X-ray spectroscopy – energiedispersive Röntgenspektroskopie
IPF inverse pole figure – inverse Polfigur
IQ image quality – Patternqualität
SE secondary electrons – Sekundärelektronen

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Source of figures

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Understanding metallurgical practices of the Únětice Culture: The axes from Halle-Kanena III and the concept of mixing metals in the Early Bronze Age

Daniel Berger, Jan-Heinrich Bunnefeld, Andreas Wittke, and Ernst Pernicka

Zusammenfassung

Zum besseren Verständnis der metallurgischen Praktiken der Aunjetitzer Kultur: Die Beile aus Halle-Kanena III und das Konzept des Metallmischens in der frühen Bronzezeit

Das Mischen und Recyceln von Metallen sind zwei für prähistorische Gesellschaften nach wie vor unterschätzte Aspekte in der archäologischen Forschung, die aufgrund ihrer schweren Nachweisbarkeit anhand vorliegender Informationen leicht übersehen und teils sogar bewusst ignoriert werden. Das Verständnis dieser Prozesse ist jedoch entscheidend, da sie erheblichen Einfluss auf chemische und isotopische Daten und sich ergebende Schlussfolgerungen haben können. Insbesondere die Mischung mehrerer Komponenten unterschiedlicher Materialien führt in den analytischen Signaturen zu Veränderungen, die Schlussfolgerungen bezüglich der Herkunft der Metalle erschweren oder sogar unmöglich machen. Das wiederum erschwert archäologische Interpretationen.

Der vorliegende Artikel stellt einen Beitrag zur Diskussion über Misch- und Recyclingprozesse in der Bronzezeit dar, indem er aufzeigt, wie die Praktiken aus wissenschaftlichen Datensätzen abgeleitet und dennoch wertvolle Erkenntnisse bezüglich Herkunftsfragen erzielt werden können. Der Fokus liegt hierbei auf frühbronzezeitlichen Kupfer- und Bronzeartefakten der Aunjetitzer Kultur in Mitteldeutschland (Circumharzer Gruppe) unter besonderer Berücksichtigung der Randleistenbeile und Ringe aus dem Depotfund von Halle-Kanena III, Sachsen-Anhalt. Die Objekte wurden chemisch und isotopisch in einem Multi-Parameteransatz aus Spurenelement- sowie Blei- und Kupferisotopenanalyse charakterisiert. Diese Strategie erwies sich als vorteilhaft bei der Identifizierung von Mischprozessen mit Kupfer, insbesondere durch das Einbeziehen von Kupferisotopendaten. Sogenannte Mischungslinien, die aus der kombinierten Auswertung der verschiedenen isotopischen und chemischen Parameter resultieren, erlauben eine weit bessere Rekonstruktion von Misch-/Recyclingprozessen als die isolierte Betrachtung einzelner Parameter. Gleichzeitig erleichtern Mischungslinien die Ermittlung der Ausgangskomponenten des verwendeten Kupfers, was wiederum die Wahrscheinlichkeit erhöht, die ursprünglichen Erzquellen trotz Mischung zu lokalisieren. Allerdings gelingt es nur durch das Einbeziehen von Informationen aus dem archäologischen Kontext und durch Beobachtungen an den Artefakten, zwischen Mischen und Recyceln zu unterscheiden, was anhand der Daten allein nicht zweifelsfrei möglich ist.

Die Studie zeigt, dass die Metallurgen der Aunjetitzer Kultur bereits in der Frühbronzezeit verschiedene Sorten von

Summary

The mixing and recycling of metals in prehistoric societies are two still underestimated aspects of archaeometallurgical research, often disregarded or overlooked due to challenges in reconstructing them from available information. However, understanding these metallurgical processes is crucial because of their significant impact on scientific data and the resulting cultural historical conclusions. Specifically, the blending of different materials leads to changes in analytical signatures, making conclusions about the origin of metals difficult or even impossible.

This article aims at contributing to the discussion on mixing and recycling processes in the Bronze Age and at illustrating how these practices can be deduced from scientific data sets. It focuses on metal artefacts from the Early Bronze Age Únětice Culture in Central Germany, with particular emphasis on flanged axes and rings from the hoard of Halle-Kanena III, Saxony-Anhalt. These items underwent chemical and isotopic characterisation through a multi-proxy approach of trace elemental as well as lead and copper isotope analysis. The application of this integrated analytical strategy, especially the inclusion of copper isotopes, proved advantageous in identifying two-component mixing processes with metals, since so-called mixing lines from the combined assessment of the different parameters can be used to reconstruct mixing/recycling with greater certainty. At the same time, mixing lines assist in determining the end members of the copper, i.e. the initial sources or raw materials mixed, used in these processes, thus increasing the likelihood of localising the original ore sources despite blending. However, only by integrating information from the archaeological context and observations of the artefacts is it possible to eventually distinguish between mixing and recycling, which is not feasible with scientific data alone.

Ultimately, the study reveals that Únětice metallurgists were adept at mixing different sorts of fahlore copper (nickel-rich fahlore copper, Ösenring *copper) as early as the Early Bronze Age, a practice argued to have occurred in the territory of the Únětice Culture itself, rather than in the copper source regions (most likely the Alps and/or the Slovakian Ore Mountains). This highlights the ability of craftspeople to handle and manipulate materials according to the requirements. But why different types of copper were mixed remains an open question. Nonetheless, the insights gained from this case study significantly enhance our understanding of Bronze Age metallurgy, affirming that copper mixing must have been a more widespread practice than hitherto assumed.*

Fahlerzkupfer (nickelreiches Fahlerzkupfer, Ösenringkupfer) mischten. Höchstwahrscheinlich fand das innerhalb des Territoriums der Aunjetitzer Kultur selbst und entgegen früheren Annahmen nicht in den Ursprungsregionen des Kupfers statt, die wahrscheinlich in den Alpen und/oder im Slowakischen Erzgebirge zu suchen sind. Das unterstreicht die Fähigkeit der Handwerker, verschiedene Materialien zu verarbeiten und entsprechend den Erfordernissen zu manipulieren. Allerdings muss der Grund für das Mischen verschiedener Kupfersorten offenbleiben. Nichtsdestotrotz erweitern die Ergebnisse dieser Fallstudie unser Verständnis der frühbronzezeitlichen Metallurgie erheblich und bestätigen, dass das Mischen von Kupfer wohl eine deutlich weiter verbreitete Praxis war als landläufig angenommen.

Schlagwörter Aunjetitzer Kultur, Frühbronzezeit, Metallurgie, Fahlerzkupfer, Metallmischen

Keywords Únětice Culture, Early Bronze Age, metallurgy, fahlore copper, metal mixing

Introduction

The Únětice Culture – extending roughly from 2200 to 1550 BC[1] – represents a crucial archaeological epoch in Central Europe and marks the transition from the Neolithic to the Early Bronze Age (EBA). Situated predominantly in the areas of present-day Germany, the Czech Republic, and Poland, the Únětice people of the various regional groups are renowned for their advanced metalworking skills and their creation of intricate and sophisticated artefacts. Thousands of metal objects, including weaponry, tools, and ornamental items, bear witness to the rich metallurgical tradition and underscore the cultural and technological achievements of the time. Objects were deposited in graves or as individual finds, but in Central Germany the vast majority was found in hoards, some of which may contain several hundreds of single items (von Brunn 1959; Meller 2019). In addition to rings, tools such as axes and weapons dominate, which is why H. Meller (2017; 2019) and R. Schwarz (2014) argue that especially the hoards from the Central German Circum-Harz group are representations of the hierarchical and military organisation of the Únětice society. Irrespective of this hypothesis, metal hoards are valuable archives of metallurgical developments over time. They provide information about the metals and alloys used, but can also yield evidence for the provenance of raw materials when the chemical and isotopic compositions are assessed. However, inferring the origins of metals may be compromised by specific techniques of metal processing such as the mixing of ores and metals, or even the recycling of material, which in turn may have a bearing on archaeological interpretations. Being aware of such practices is therefore key to understanding the cultural heritage, but identifying objects made from mixed or recycled material, not to mention quantifying the amount of such objects within a collection, is a challenging task. These considerations are all the more topical as there has been growing evidence over the last decade that the mixing of metals was practiced more often than has previously been assumed, even in the EBA[2].

The axes of the Únětice Culture and the Circum-Harz group in particular are predestined to serve as objects in any investigation of this topic (see Bunnefeld et al. in this volume). Firstly, there is a plethora of over 1000 axes from across the entire region, which derive from secured and closed archaeological contexts. Most of them were found associated in c. 35 hoards surrounding the Harz Mountains, some containing anywhere from 50 up to 300 axes, in addition to other artefacts (Fig. 1). There is thus a large proportion of directly related artefacts. Secondly, axes are typologically well defined and can be dated by associated finds, which helps to monitor metallurgical developments over time. And, thirdly, axes occur from the early Únětice Culture c. 2000 BC until its very end around 1550 BC, and thus the metal composition in the hoards can be perceived as a reflection of the usage of copper and its alloys.

All these aspects are expedient prerequisites for reconstructing mixing processes. The most important factor, however, is the availability of a large set of analytical data, as most metal objects of the German branch of the Únětice Culture were analysed in the past during the FMZM[3] and FOR 550[4] projects. These datasets have recently been extended by analyses during the BronzeAgeTin project[5], adding in particular data from new analytical tools such as tin and copper isotopy. Thanks to these initiatives, we now have a very good

1 Zich 1996; Bartelheim 1998; Schwarz 2019; Schwarz 2021.

2 Melheim 2015; Stöllner et al. 2016; Grutsch et al. 2019; Mödlinger et al. 2021; Nørgaard et al. 2021; Berger et al. 2022; Berger et al. 2022a; Berger et al. 2023.

3 FMZM = Project »Frühe Metallurgie im zentralen Mitteleuropa«, funded by the Volkswagen Stiftung with a total of 2400 individual analyses of metal objects using X-ray fluorescence analysis.

4 FOR 550 = Research group »Der Aufbruch zu neuen Horizonten: Die Funde von Nebra, Sachsen-Anhalt, und ihre Bedeutung für die Bronzezeit Europas«, funded by the Deutsche Forschungsgemeinschaft, 2003–2010, with a total of 718 individual analyses of Neolithic and EBA metal objects using X-ray fluorescence analysis and approx. 300 lead isotope and copper isotope analyses.

5 BronzeAgeTin = ERC-Project »Tin Isotopes and the Sources of Bronze Age Tin in the Old World«, funded by the European Research Council (ERC) from 2013–2018.

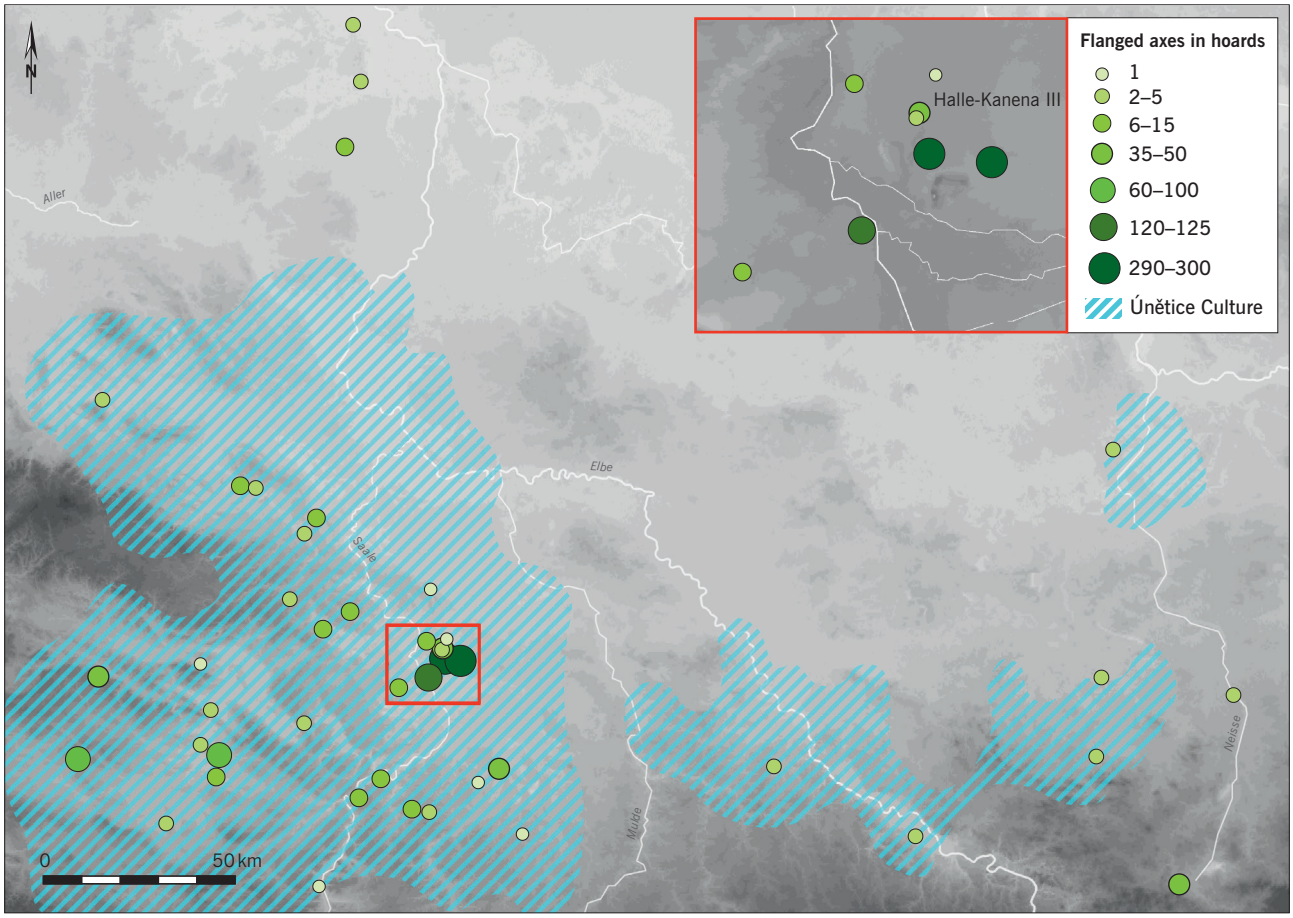

Fig. 1 The geographic distribution of the Circum-Harz group (left half of the map) of the Únětice Culture and locations of metal hoards with flanged axes. In the micro-region around Halle and Dieskau (map inset), several hoards with 50 to 300 objects were discovered, including the Halle-Kanena III assemblage.

Abb. 1 *Die geografische Verbreitung der Circumharzer Gruppe (linke Kartenhälfte) der Aunjetitzer Kultur und die Fundorte der Metallhorte mit Randleistenbeilen. In der Mikroregion rund um Halle und Dieskau (Kartenausschnitt) wurden mehrere Horte mit 50 bis 300 Objekten entdeckt, darunter das Depot III von Halle-Kanena.*

understanding of the metallurgy of the Únětice Culture, its organisation and the procurement and processing of metal.

It was a time when bronze was first utilised extensively in Central Europe, and the use of various copper types evolved over time (Nørgaard et al. 2021). Arsenical copper dominated the earliest phase, followed by either tin-free or tin-containing nickel-rich fahlore and *Ösenring* copper as well as fahlore copper with varying nickel contents in the classical Únětice phase. In its later phase, a transition from high-impurity fahlore copper to low-impurity chalcopyrite copper is observed along with an increase in tin concentrations in bronzes (Lutz et al. 1998; Rassmann 2010; Lockhoff et al. 2019). The metallurgists of the Únětice Culture apparently had access to only a limited number of sources with specific ore types; an observation that applies also to other Central European cultural regions (Krause/Pernicka 1998; Krause 2003). The location of these ore sources remained largely unclear for a long time, but thanks to an enlarged database of lead isotope ratios and trace elements of both (Únětice) metal objects and copper ores, we now have the right tools at hand to uncover the provenance of the specific copper types. On the other hand, new isotope methods developed in the last 20 years can significantly contribute to disentangling the relationships of artefacts. They paved the way to a more holistic study of the material. By using copper isotopes, for example, N. Lockhoff et al. (2019) were able to differentiate the various copper types of the Únětice Culture by their isotope values. This was an important result, as was the observation that the widespread fahlore copper type with variable nickel concentrations shows a distinct parallel alignment of data points with little or no change in the silver concentration at c. 1 % combined with large variations of nickel in the objects (Fig. 2; Lutz et al. 1998; Krause 2003, 198; Lockhoff et al. 2019). Since there is no obvious explanation for this arrangement, Lockhoff et al. (2019, 137–138) suggested that artefacts consisting of nickel-rich fahlore copper may have been mixed with artefacts of copper resembling the classical *Ösenring* copper. Ultimately, the authors were unable to substantiate this hypothesis based on their data.

This is where our work comes in. We take up the hypothesis of metal mixing again, whereby we draw on a larger number of isotopic and chemical data and evaluate these in combination with each other. The Halle-Kanena III hoard in Saxony-Anhalt from the classical Únětice phase serves as an example, not least because it has been extensively analysed, but also because all three copper types are associated in this assemblage.

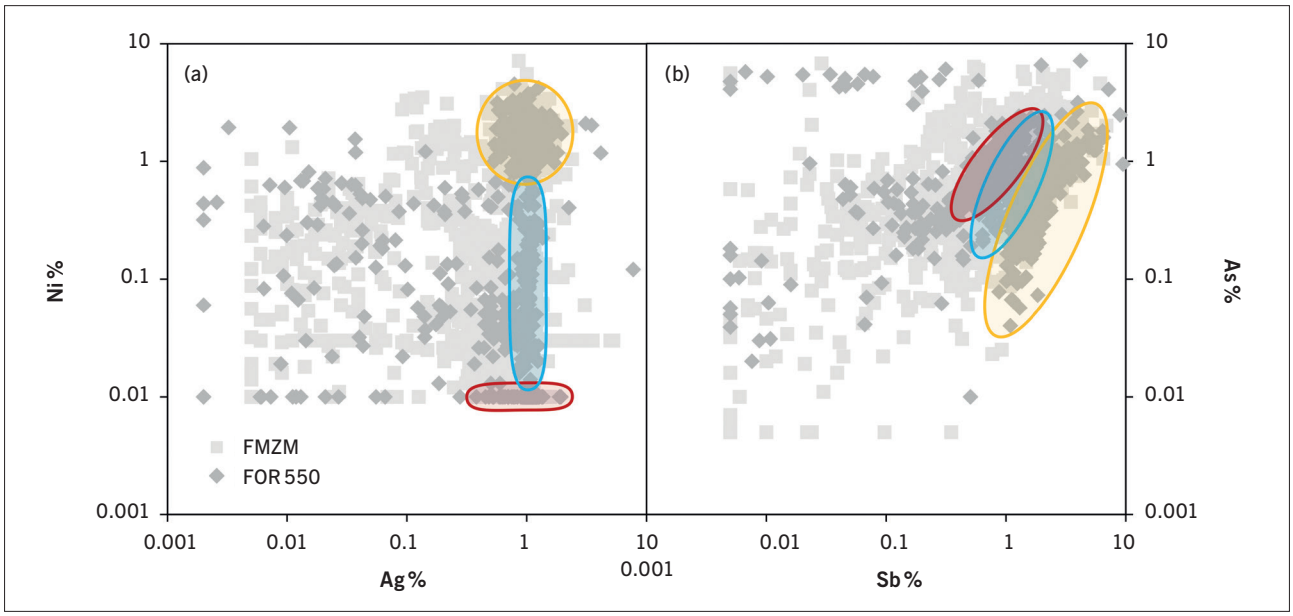

Fig. 2a–b Bi-variate plots of silver (Ag) versus nickel (Ni) and antimony (Sb) versus arsenic (As) of metal artefacts from the Central German Únětice Culture analysed in the FMZM and FOR 550 projects. The ellipses show the typical composition of nickel-rich fahlore copper (orange), *Ösenring* copper (red), and copper with variable nickel (blue). Note the pronounced alignment of Ag-Ni data of the variable nickel copper parallel to the y-axis.

Abb. 2a–b *Bivariate Streudiagramme der Anteile von Silber (Ag) gegen Nickel (Ni) und Antimon (Sb) gegen Arsen (As) von Metallartefakten aus der mitteldeutschen Aunjetitzer Kultur, die im Rahmen der Projekte FMZM und FOR 550 analysiert wurden. Die Ellipsen zeigen die charakteristische Zusammensetzung nickelreichen Fahlerzkupfers (orange), Ösenringkupfers (rot) und Kupfers mit variablen Nickelanteilen (blau). Man beachte die auffällige Anordnung der Ag-Ni-Daten des Fahlerzkupfers mit variablem Nickelanteil parallel zur Y-Achse.*

The Halle-Kanena III hoard

The Halle-Kanena III hoard was discovered in 1934 during mining operations in the former lignite mine »Alwine« in the eastern part of Halle (Saale), Germany, close to the sites of two other hoards (Halle-Kanena I and II) found somewhat earlier (von Brunn 1959, 59). They add to a series of large hoard finds of the EBA in the vicinity (Halle, Dieskau I–III, Gröbers-Bennewitz, Schkopau), making the micro-region around Halle and Dieskau, Saalekreis district, one of the richest within the whole Únětice Culture (Fig. 1; e.g., Filipp/Freudenreich 2014; Bunnefeld et al. 2021).

Hoard III from Halle-Kanena dates to the classical Únětice phase, c. 1900–1775 BC; in total, 61 objects were found here, carefully placed within a ceramic vessel (Tab. 1). The hoard comprises four *Ösenrings* (partly fragmentary), five heavy, oval and open rings, three arm spirals (one notably thick), one halberd blade, and 48 axes (Fig. 3–5; von Brunn 1959, 59 Pl. 41,5–43). All axes are of the flanged variant and belong to the prevalent Saxon type during this period. Numerous axes exhibit subtle or pronounced signs of extensive use, while others could probably be viewed as intermediate products (Fig. 6–7; Tab. 1). Certain of these pieces show significant flaws from casting, likely deemed spoiled castings (see Bunnefeld et al. in this volume). Metallographic examinations of two axes from the assemblage revealed that, after casting in stone, clay or sand moulds, the blanks were forged at the flanges and the blade to achieve the final shape to the axes (see Michael et al. in this volume).

Chemical and isotopic composition of the Halle-Kanena III objects

The Halle-Kanena III assemblage underwent comprehensive analytical examination as part of the FOR 550 and BronzeAgeTin projects[6]. All items were drilled for this purpose to extract samples of pure metal shavings, which were then subjected to analysis using energy dispersive X-ray fluorescence spectroscopy (EDXRF)[7] at the Curt-Engelhorn-Zentrum Archäometrie Mannheim (CEZA), Germany. The analysis by EDXRF closely adhered to the method outlined by Lutz/Pernicka (1996). Additionally, three-quarters of the samples were characterised for their isotopic composition with multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS) at CEZA[8]. This involved determining the lead and copper isotope composition of 40 and 30 items, respectively. Tin isotope values were specifically determined for a few artefacts, revealing them to be either bronzes or possessing elevated tin contents. For detailed information on the isotopic measurements, readers can refer to the relevant literature[9].

6 Only the halberd blade (HK 34:305k; MA-071653) was analysed before these two projects by Otto 1950; Otto incorrectly assigned the object to hoard II from Halle-Kanena, which does not contain a halberd blade.

7 The device used: ARL Quant'X EDXRF spectrometer, Thermo Fisher Scientific. Quantification occurred using a set of copper and copper alloy reference materials.

8 The device used: Neptune Plus HR-MC-ICP-MS, Thermo Fisher Scientific.

9 Niederschlag et al. 2003; Brügmann et al. 2017; Berger et al. 2022; Berger et al. 2022a.

Sample no.	Inventory no.	Object	Analyses
MA-071652	HK 34:305i	Arm spiral	EDXRF
MA-071653	HK 34:305k	Halberd blade	EDXRF, LIA
MA-071668	HK 34:305b	*Ösenring*	EDXRF, LIA
MA-071669	HK 34:305d	Massive ring	EDXRF, LIA; CIA, TIA
MA-071670	HK 34:305m	*Ösenring*	EDXRF, LIA; CIA
MA-071671	HK 34:305c	*Ösenring*	EDXRF, LIA
MA-071672	HK 34:305n	Massive ring	EDXRF, LIA; CIA, TIA
MA-071673	HK 34:305f	Massive ring	EDXRF, LIA; CIA, TIA
MA-071674	HK 34:305e	Massive ring	EDXRF
MA-071675	HK 34:305g	Massive ring	EDXRF, LIA
MA-071676	HK 34:305a	*Ösenring*	EDXRF
MA-071706	HK 34:305h	Arm spiral	EDXRF, LIA
MA-071780	HK 34:305l, 33	Flanged axe	EDXRF, LIA
MA-071781	HK 34:305l, 03	Flanged axe	EDXRF, LIA
MA-071782	HK 34:305o, 09	Flanged axe	EDXRF, LIA; CIA
MA-071783	HK 34:305l, 31	Flanged axe	EDXRF, LIA
MA-071784	HK 34:305l, 04	Flanged axe	EDXRF, LIA; CIA
MA-071832	HK 34:305l, 11	Flanged axe	EDXRF, LIA
MA-071833	HK 34:305o, 10	Flanged axe	EDXRF; CIA
MA-071834	HK 34:305l, 15	Flanged axe	EDXRF, LIA
MA-071861	HK 34:305o, 4	Flanged axe	EDXRF; CIA
MA-071862	HK 34:305l, 20	Flanged axe	EDXRF
MA-071863	HK 34:305l, 1	Flanged axe	EDXRF, LIA; CIA
MA-071864	HK 34:305o, 1	Flanged axe	EDXRF, LIA; CIA, TIA
MA-071865	HK 34:305l, 12	Flanged axe	EDXRF, LIA; CIA
MA-071866	HK 34:305l, 2	Flanged axe	EDXRF; CIA
MA-071867	HK 34:305l, 21	Flanged axe	EDXRF; CIA
MA-071868	HK 34:305l, 23	Flanged axe	EDXRF; CIA
MA-071869	HK 34:305l, 14	Flanged axe	EDXRF, LIA; CIA
MA-071870	HK 34:305o, 12	Flanged axe	EDXRF
MA-071871	HK 34:305l, 32	Flanged axe	EDXRF, LIA; CIA
MA-071872	HK 34:305l, 34	Flanged axe	EDXRF, LIA; CIA
MA-071873	HK 34:305l, 35	Flanged axe	EDXRF, LIA; CIA
MA-071874	HK 34:305o, 11	Flanged axe	EDXRF
MA-071875	HK 34:305o, 2	Flanged axe	EDXRF
MA-071876	HK 34:305o, 8	Flanged axe	EDXRF
MA-071877	HK 34:305l, 10	Flanged axe	EDXRF; CIA
MA-071878	HK 34:305l, 17	Flanged axe	EDXRF
MA-071879	HK 34:305o, 6	Flanged axe	EDXRF
MA-071880	HK 34:305l, 25	Flanged axe	EDXRF, LIA
MA-071881	HK 34:305l, 28	Flanged axe	EDXRF, LIA; CIA
MA-071882	HK 34:305l, 5	Flanged axe	EDXRF, LIA; CIA
MA-071883	HK 34:305l, 18	Flanged axe	EDXRF, LIA
MA-071884	HK 34:305o, 3	Flanged axe	EDXRF, LIA
MA-071885	HK 34:305l, 9	Flanged axe	EDXRF; CIA
MA-071886	HK 34:305o, 5	Flanged axe	EDXRF, LIA
MA-071887	HK 34:305l, 30	Flanged axe	EDXRF
MA-071888	HK 34:305l, 7	Flanged axe	EDXRF, LIA; CIA
MA-071889	HK 34:305o, 7	Flanged axe	EDXRF, LIA; CIA
MA-071890	HK 34:305l, 27	Flanged axe	EDXRF, LIA; CIA
MA-071891	HK 34:305l, 26	Flanged axe	EDXRF, LIA; CIA
MA-071892	HK 34:305l, 19	Flanged axe	EDXRF, LIA
MA-071893	HK 34:305l, 13	Flanged axe	EDXRF, LIA; CIA
MA-071894	HK 34:305l, 6	Flanged axe	EDXRF, LIA; CIA
MA-071895	HK 34:305l, 36	Flanged axe	EDXRF; CIA
MA-071896	HK 34:305e, 22	Flanged axe	EDXRF, LIA; CIA, TIA
MA-071897	HK 34:305l, 29	Flanged axe	EDXRF, LIA
MA-071898	HK 34:305l, 24	Flanged axe	EDXRF
MA-071899	HK 34:305e, 08	Flanged axe	EDXRF, LIA; CIA, TIA
MA-071900	HK 34:305l, 16	Flanged axe	EDXRF, LIA; CIA

Tab. 1 List of analysed objects from the Halle-Kanena III hoard (with inventory nos. of the State Office for Heritage Management and Archaeology Saxony-Anhalt in Halle). The analytical methods in column 4 are: EDXRF – energy-dispersive X-ray fluorescence spectrometry; CIA – copper isotope analysis; LIA – lead isotope analysis; TIA – tin isotope analysis.

Tab. 1 *Liste der analysierten Objekte aus Depot III von Halle-Kanena. Bei den Analyseverfahren in der vierten Spalte handelt es sich um: EDXRF – energiedispersive Röntgenfluoreszenzspektrometrie; CIA – Kupferisotopenanalyse; LIA – Bleiisotopenanalyse; TIA – Zinnisotopenanalyse.*

As outlined in the introduction, the Únětice Culture resorted to a specific range of copper types, the usage of which evolved over time. Notably, during the classical Únětice phase, there was a distinct prevalence of high-impurity fahlore copper, deriving from ores containing minerals of the tennantite-tetrahedrite series. Depending on the composition of these mostly sulphidic copper ores, the smelted copper could contain impurities in the percentage range, especially of arsenic and antimony, but also of silver and bismuth (Fig. 2). Typically, arsenic and antimony dominate, but their specific proportions in the metal inherently rely on the ratio of tennantite ($Cu_6As_4S_{13}$) and tetrahedrite ($Cu_6Sb_4S_{13}$) in the smelted ore charge, as well as the smelting conditions[10]. The contents of these elements serve as a criterion for copper classification, alongside the presence of further elements such as bismuth, silver, and nickel (Junghans

10 It has to be assumed that these ores were roasted before smelting, which would remove large parts of arsenic and antimony as oxides (Tylecote et al. 1977; Pernicka 1999).

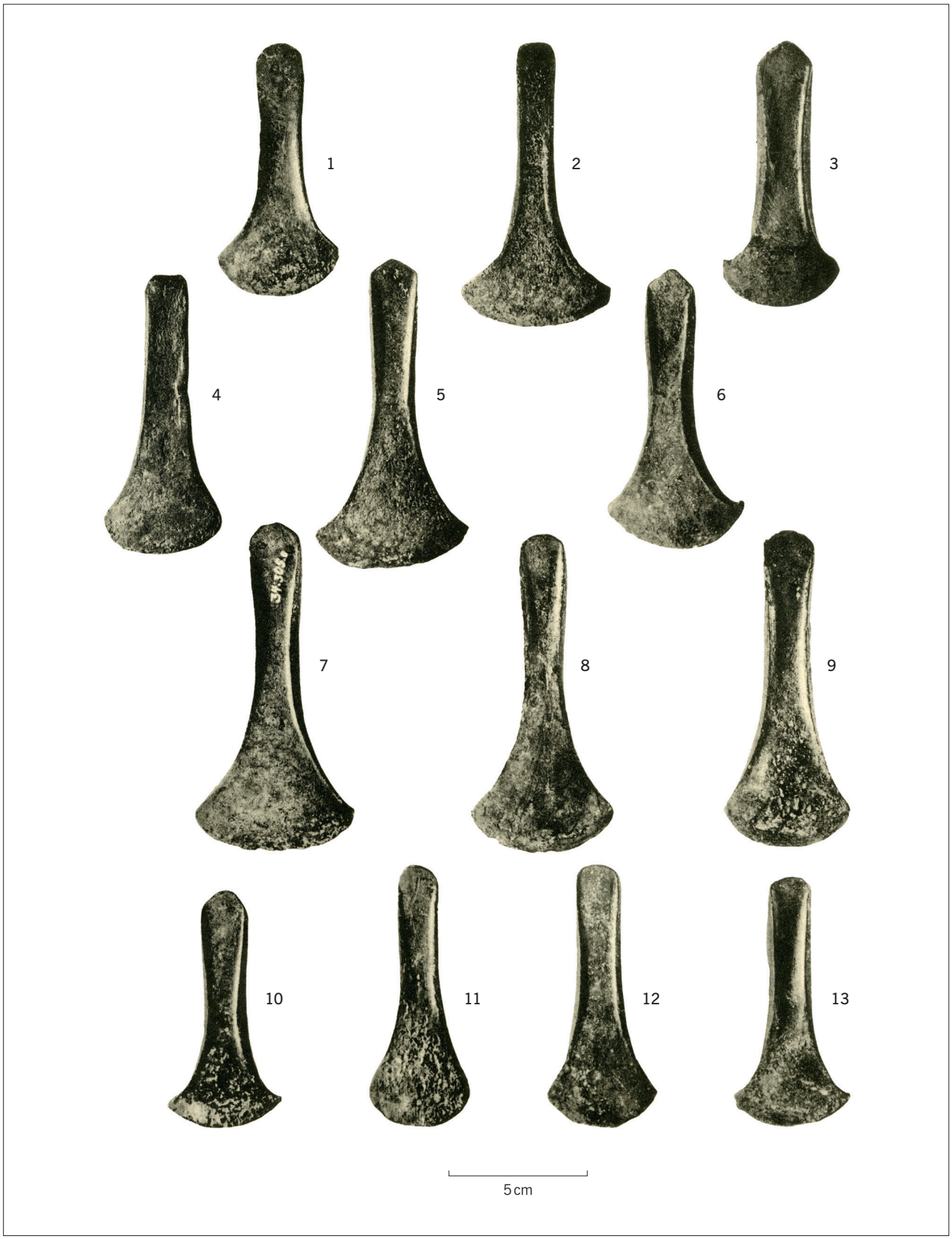

Fig. 3 13 axes of 48 overall from the Halle-Kanena III hoard on an old image in the publication of von Brunn 1959.

Abb. 3 *13 von insgesamt 48 Beilen aus Depot III von Halle-Kanena auf einer alten Abbildung in der Veröffentlichung von Brunn 1959.*

et al. 1960; Junghans et al. 1968). Even though the latter does not derive from fahlore minerals directly, because they cannot accommodate nickel in the crystal lattice, the fahlore copper can be subdivided into types with elevated and varying nickel concentrations, on the one hand, and the fahlore copper type without nickel but with high silver and bis-

Fig. 4 Four massive rings and the halberd from the Halle-Kanena III hoard.

Abb. 4 *Vier massive Ringe und die Stabdolchklinge aus Depot III von Halle-Kanena.*

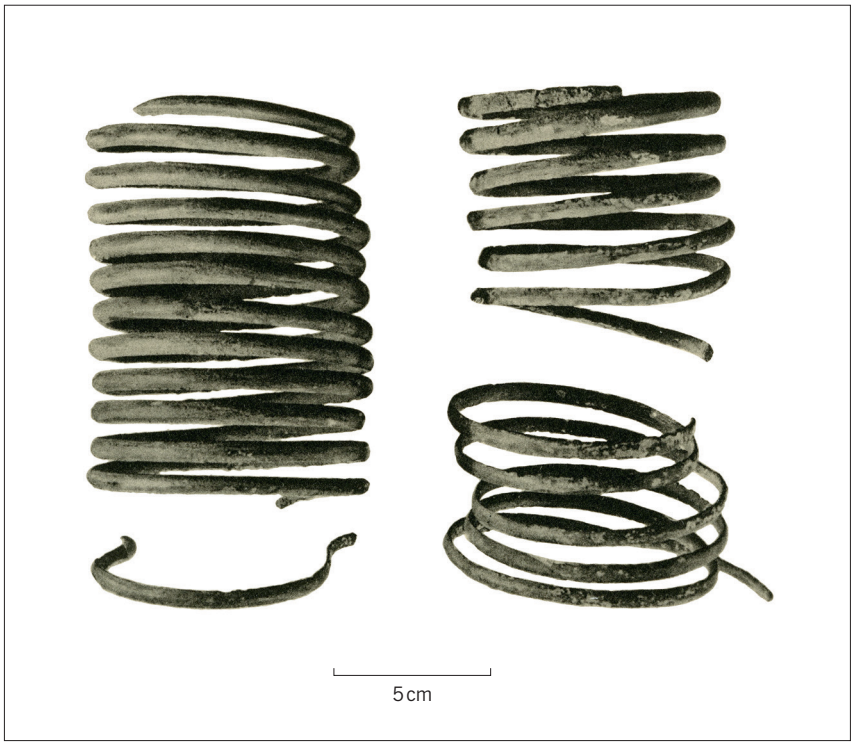

Fig. 5 Arm spirals from the Halle-Kanena III hoard.

Abb. 5 *Armspiralen aus Depot III von Halle-Kanena.*

Fig. 6 Some axes from Halle-Kanena III with inventory numbers of the State Office for Heritage Management and Archaeology Saxony-Anhalt in Halle (Saale) and laboratory numbers of CEZA (cf. Tab. 1). Exemplarily shown here are three axes from copper with variable nickel concentrations (top panel), two from nickel-rich copper (centre panel) and three from *Ösenring* copper (bottom panel). They show no differences in typology.

Abb. 6 *Einige Beile aus Depot III von Halle-Kanena mit Inventarnummern des Landesamtes für Denkmalpflege und Archäologie Sachsen-Anhalt in Halle (Saale) und Labornummern des Curt-Engelhorn-Zentrums Archäometrie Mannheim (vgl. Tab. 1). Beispielhaft abgebildet sind drei Kupferbeile mit variablem Nickelanteil (oben), zwei Beile aus nickelreichem Kupfer (Mitte) und drei Beile aus Ösenringkupfer (unten), die typologisch keine Unterschiede zeigen.*

muth, commonly known as classical *Ösenring* copper, on the other[11]. In later periods, fahlore copper with generally lower nickel and silver supersedes the other copper types of the Únětice Culture, marking a gradual shift towards low-impurity chalcopyrite copper at the end of the Únětice Culture. Arsenical copper also exists but is largely confined to the

earliest Únětice phases (before 2000 BC) as a relic from the Chalcolithic era (Rassmann 2010, 815; Lockhoff et al. 2019).

The metal composition of the Halle-Kanena III finds closely mirrors the broader metallurgical pattern on a smaller scale. The collection encompasses most of the copper types named above, with fahlore copper containing high, varying, and very low quantities of nickel being the predominant materials used for the majority of the artefacts (Fig. 8; Tab. 2). Only the halberd blade and one of the axes consist of arsenical and low-impurity copper, respectively (see also Otto 1950). Twelve objects, including axes, massive rings, and a spiral arm ring, fall into the category of nickel-rich fahlore copper exhibiting nickel contents from over 1 % to almost 4 %[12]. In these items, arsenic levels vary between 0.3 % and 1.9 %, whereas antimony consistently ranges from 1 % to 5 %. Interestingly, the five massive arm rings are the only proper bronzes in the hoard, with tin contents from 5 % to 13 %, but they also show the highest contents of antimony (up to 5 %), which is quite unusual. The spiral ring and the axes, on the other hand, either have no tin or contain only very low concentrations between 0.1 % and 0.4 %. However, all artefacts with high nickel have low bismuth (< 0.01–0.03 %) and lead (< 0.01–0.13 %) concentrations in common and exhibit a very narrow range of silver concentrations of around 1 %, which averages to 1.02 ± 0.19 % for the rings and to 0.95 ± 0.27 % for the axes (Tab. 2).

A very similar silver average of 1.05 ± 0.26 % was determined for the twenty objects crafted from *Ösenring* copper (Tab. 2). This set includes four *Ösenrings*, which are known to have been mainly produced from this copper type and

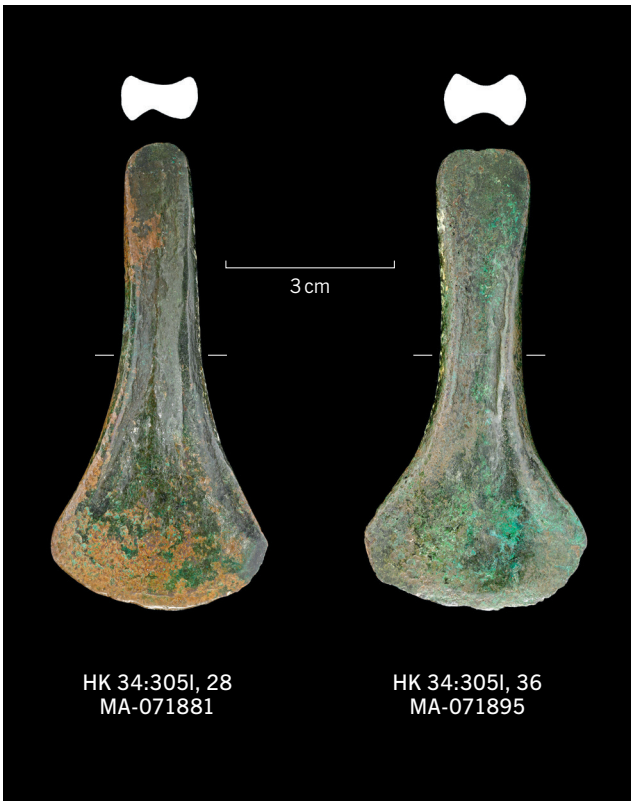

Fig. 7 Two blank axes from Halle-Kanena III without elaborated flanges and sharpened cutting edges intended to be shaped into final axes.

Abb. 7 *Zwei Beilrohlinge aus Depot III von Halle-Kanena ohne ausgearbeitete Randleisten und geschärfte Schneiden, aus denen gebrauchsfähige Beile entstehen sollten.*

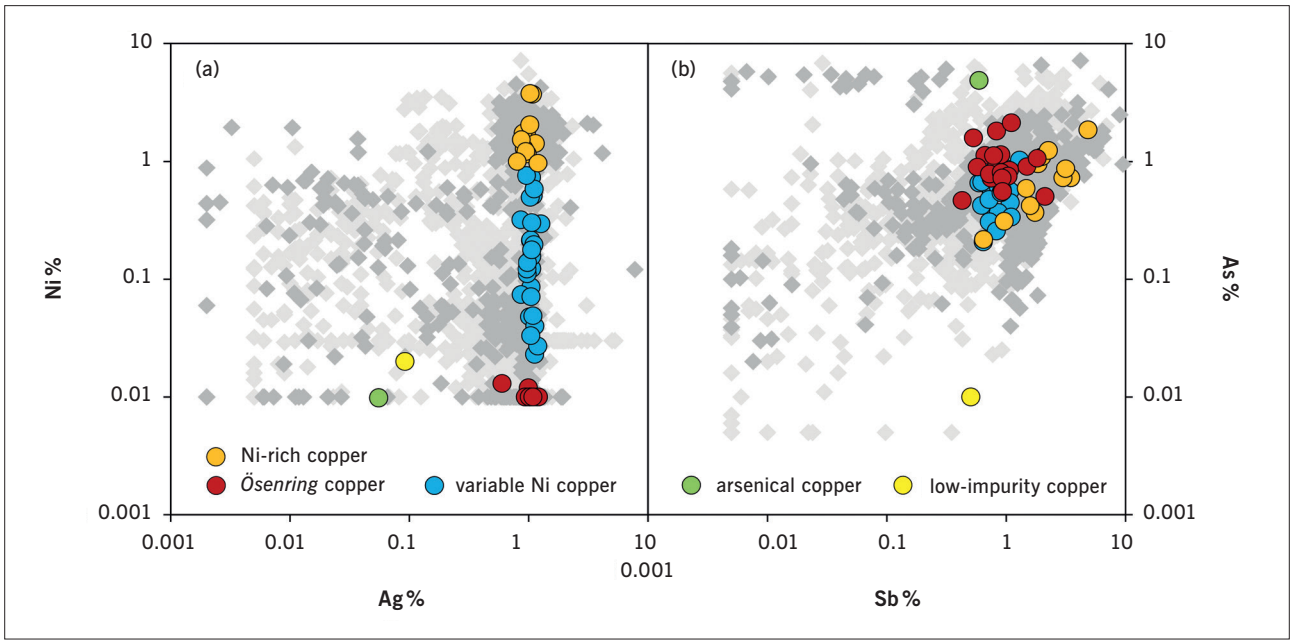

Fig. 8a–b Chemical composition of the objects from Halle-Kanena III categorised by metal types. For data see Tab. 2; all data in mass%.

Abb. 8a–b *Chemische Zusammensetzung der Objekte aus Depot III von Halle-Kanena nach Metallarten. Daten siehe Tab. 2; alle Angaben in Massenprozent.*

11 Butler 1979; Krause/Pernicka 1998; Junk et al. 2001; Krause 2003; Rassmann 2010; Lutz/Pernicka 2013; Lockhoff et al. 2019.

12 All element concentrations in this article are reported in mass%.

Sample no.	Inventory no.	Copper type	Cu%	Fe%	Co%	Ni%	Zn%
MA-071669	Halle 34:305d	Nickel-rich copper (with Sn)	80	<0.02	0.18	1.74	<0.2
MA-071672	Halle 34:305n	Nickel-rich copper (with Sn)	79	0.04	0.89	3.7	<0.2
MA-071673	Halle 34:305f	Nickel-rich copper (with Sn)	80	<0.02	0.06	1.73	<0.2
MA-071674	Halle 34:305e	Nickel-rich copper (with Sn)	88	0.02	0.07	2.04	<0.2
MA-071675	Halle 34:305g	Nickel-rich copper (with Sn)	85	<0.02	0.04	1.42	<0.2
Average			**83**		**0.25**	**2.13**	
2SD			**8**		**0.73**	**1.82**	
MA-071706	Halle 34:305h	Nickel-rich copper	92	0.05	0.04	3.8	0.3
MA-071782	Halle 34:305o, 9	Nickel-rich copper	96	<0.02	<0.01	1.16	<0.2
MA-071784	Halle 34:305l, 4	Nickel-rich copper	94	<0.02	<0.01	1.28	<0.2
MA-071833	Halle 34:305o, 10	Nickel-rich copper	95	<0.02	0.02	1.53	<0.2
MA-071864	Halle 34:305o, 1	Nickel-rich copper	96	0.02	0.01	1.21	0.2
MA-071867	Halle 34:305l, 21	Nickel-rich copper	94	<0.02	0.07	0.97	<0.2
MA-071895	Halle 34:305l, 36	Nickel-rich copper	97	<0.02	<0.01	1.00	<0.2
Average			**95**	**0.02**	**0.02**	**1.19**	
2SD			**2**	**0.00**	**0.05**	**0.41**	
MA-071783	Halle 34:305l, 31	Variable nickel copper, Group I	98	<0.02	<0.01	0.12	<0.2
MA-071832	Halle 34:305l, 11	Variable nickel copper, Group I	97	<0.02	<0.01	0.32	<0.2
MA-071862	Halle 34:305l, 20	Variable nickel copper, Group I	98	<0.02	<0.01	0.02	<0.2
MA-071870	Halle 34:305o, 12	Variable nickel copper, Group I	97	<0.02	<0.01	0.09	<0.2
MA-071874	Halle 34:305o, 11	Variable nickel copper, Group I	97	<0.02	<0.01	0.05	<0.2
MA-071875	Halle 34:305o, 2	Variable nickel copper, Group I	97	<0.02	<0.01	0.21	<0.2
MA-071876	Halle 34:305o, 8	Variable nickel copper, Group I	98	<0.02	<0.01	0.07	<0.2
MA-071877	Halle 34:305l, 10	Variable nickel copper, Group I	97	<0.02	<0.01	0.22	<0.2
MA-071884	Halle 34:305o, 3	Variable nickel copper, Group I	97	<0.02	<0.01	0.16	<0.2
MA-071886	Halle 34:305o, 5	Variable nickel copper, Group I	96	<0.02	<0.01	0.03	<0.2
MA-071888	Halle 34:305l, 7	Variable nickel copper, Group I	97	<0.02	<0.01	0.11	<0.2
MA-071892	Halle 34:305l, 19	Variable nickel copper, Group I	97	<0.02	<0.01	0.29	<0.2
MA-071894	Halle 34:305l, 6	Variable nickel copper, Group I	98	<0.02	<0.01	0.04	<0.2
MA-071897	Halle 34:305l, 29	Variable nickel copper, Group I	97	<0.02	<0.01	0.20	<0.2
MA-071898	Halle 34:305l, 24	Variable nickel copper, Group I	98	<0.02	<0.01	0.03	<0.2
Average			**97**			**0.13**	
2SD			**1**			**0.20**	
MA-071861	Halle 34:305o, 4	Variable nickel copper, Group II	98	<0.02	<0.01	0.07	<0.2
MA-071865	Halle 34:305l, 12	Variable nickel copper, Group II	97	<0.02	<0.01	0.18	<0.2
MA-071866	Halle 34:305l, 2	Variable nickel copper, Group II	98	<0.02	<0.01	0.05	<0.2
MA-071868	Halle 34:305l, 23	Variable nickel copper, Group II	97	<0.02	<0.01	0.14	<0.2
MA-071872	Halle 34:305l, 34	Variable nickel copper, Group II	97	<0.02	<0.01	0.30	<0.2
MA-071885	Halle 34:305l, 9	Variable nickel copper, Group II	97	<0.02	<0.01	0.12	<0.2
MA-071889	Halle 34:305o, 7	Variable nickel copper, Group II	97	<0.02	<0.01	0.73	<0.2
MA-071891	Halle 34:305l, 26	Variable nickel copper, Group II	97	<0.02	0.035	0.51	<0.2
MA-071893	Halle 34:305l, 13	Variable nickel copper, Group II	97	<0.02	<0.01	0.58	<0.2
MA-071896	Halle 34:305e, 22	Variable nickel copper, Group II	97	0.02	0.01	0.76	0.2
MA-071900	Halle 34:305l, 16	Variable nickel copper, Group II	97	<0.02	<0.01	0.49	<0.2
Average			**97**			**0.36**	
2SD			**1**			**0.53**	
MA-071652	Halle 34:305i	*Ösenring* copper	97	<0.02	<0.01	<0.01	<0.2
MA-071668	Halle 34:305b	*Ösenring* copper	97	<0.02	0.03	0.01	<0.2

As%	Se%	Ag%	Sn%	Sb%	Te%	Au%	Pb%	Bi%
0.72	<0.005	0.96	12.3	3.5	0.013	<0.01	0.02	<0.01
1.85	<0.005	1.07	7.9	4.9	<0.005	<0.01	0.13	<0.01
0.72	<0.005	0.90	13.2	3.0	0.006	<0.01	0.02	<0.01
0.87	<0.005	1.02	4.7	3.2	<0.005	<0.01	0.02	<0.01
0.59	<0.005	1.14	10.0	1.48	<0.005	<0.01	<0.01	<0.01
0.95		**1.02**	**9.6**	**3.2**			**0.04**	
1.03		**0.19**	**6.9**	**2.4**			**0.10**	
0.95	<0.005	1.03	0.136	1.86	<0.005	<0.01	0.03	<0.01
0.31	<0.005	0.97	0.39	0.96	<0.005	<0.01	<0.01	<0.01
1.09	<0.005	0.92	0.060	1.99	<0.005	<0.01	0.06	<0.01
0.37	<0.005	0.87	0.098	1.75	<0.005	<0.01	0.03	<0.01
0.42	0.005	0.94	0.12	1.60	0.005	<0.01	0.01	0.01
1.24	<0.005	1.20	<0.005	2.26	<0.005	<0.01	0.02	0.03
0.22	<0.005	0.80	0.110	0.65	<0.005	<0.01	<0.01	<0.01
0.61		**0.95**	**0.13**	**1.53**				
0.88		**0.27**	**0.27**	**1.23**				
0.37	<0.005	1.06	<0.005	0.78	<0.005	<0.01	0.06	0.01
0.89	<0.005	0.86	<0.005	0.82	<0.005	<0.01	<0.01	<0.01
0.28	<0.005	1.12	<0.005	0.79	<0.005	<0.01	0.07	0.01
0.56	<0.005	1.05	<0.005	1.07	<0.005	<0.01	<0.01	0.05
0.75	<0.005	1.02	<0.005	0.76	<0.005	<0.01	<0.01	0.02
0.45	<0.005	1.04	<0.005	1.08	<0.005	<0.01	<0.01	0.02
0.58	<0.005	0.86	<0.005	0.74	<0.005	<0.01	<0.01	0.02
0.66	<0.005	1.04	<0.005	0.59	<0.005	<0.01	<0.01	0.01
0.74	<0.005	1.06	<0.005	0.70	<0.005	<0.01	<0.01	<0.01
1.03	<0.005	1.19	<0.005	1.30	<0.005	<0.01	<0.01	0.08
0.89	<0.005	0.97	<0.005	0.96	<0.005	<0.01	<0.01	0.02
0.55	<0.005	1.26	<0.005	0.76	<0.005	<0.01	<0.01	<0.01
0.42	<0.005	1.13	<0.005	0.62	<0.005	<0.01	<0.01	<0.01
0.73	<0.005	1.10	<0.005	0.74	<0.005	<0.01	<0.01	<0.01
0.67	<0.005	1.04	<0.005	0.63	<0.005	<0.01	<0.01	<0.01
0.65		**1.05**		**0.83**				**0.02**
0.40		**0.22**		**0.41**				**0.04**
0.47	<0.005	1.04	0.130	0.72	<0.005	<0.01	<0.01	<0.01
0.61	<0.005	1.06	0.071	0.86	<0.005	<0.01	<0.01	<0.01
0.21	<0.005	1.08	0.009	0.64	<0.005	<0.01	<0.01	0.01
0.86	<0.005	0.98	0.070	0.82	<0.005	<0.01	<0.01	<0.01
0.37	<0.005	1.06	0.092	0.86	<0.005	<0.01	<0.01	<0.01
0.97	<0.005	0.97	0.027	0.69	<0.005	<0.01	<0.01	0.02
0.57	<0.005	1.05	0.161	0.93	<0.005	<0.01	<0.01	0.01
0.31	<0.005	1.09	0.093	0.72	<0.005	<0.01	<0.01	<0.01
0.26	<0.005	1.11	0.175	0.83	<0.005	<0.01	<0.01	<0.01
0.34	0.005	0.96	0.193	1.10	0.005	<0.01	0.01	0.01
0.54	<0.005	1.03	0.158	0.91	0.007	<0.01	<0.01	<0.01
0.50		**1.04**	**0.11**	**0.82**				**0.01**
0.49		**0.10**	**0.12**	**0.26**				**0.00**
1.58	<0.005	0.95	<0.005	0.53	<0.005	<0.01	<0.01	<0.01
0.90	<0.005	0.59	<0.005	1.49	<0.005	<0.01	<0.01	0.02

Continued on next page

Sample no.	Inventory no.	Copper type	Cu%	Fe%	Co%	Ni%	Zn%
MA-071670	Halle 34:305m	*Ösenring* copper	96	<0.02	<0.01	<0.01	<0.2
MA-071671	Halle 34:305c	*Ösenring* copper	96	<0.02	<0.01	0.012	<0.2
MA-071676	Halle 34:305a	*Ösenring* copper	96	<0.02	<0.01	<0.01	<0.2
MA-071780	Halle 34:305l, 33	*Ösenring* copper	97	<0.02	<0.01	<0.01	<0.2
MA-071781	Halle 34:305l, 03	*Ösenring* copper	97	<0.02	<0.01	<0.01	<0.2
MA-071834	Halle 34:305l, 15	*Ösenring* copper	97	<0.02	<0.01	<0.01	<0.2
MA-071869	Halle 34:305l, 14	*Ösenring* copper	97	<0.02	<0.01	0.01	<0.2
MA-071871	Halle 34:305l, 32	*Ösenring* copper	98	<0.02	<0.01	<0.01	<0.2
MA-071873	Halle 34:305l, 35	*Ösenring* copper	97	<0.02	<0.01	<0.01	<0.2
MA-071878	Halle 34:305l, 17	*Ösenring* copper	97	<0.02	<0.01	<0.01	<0.2
MA-071879	Halle 34:305o, 6	*Ösenring* copper	96	<0.02	<0.01	<0.01	<0.2
MA-071880	Halle 34:305l, 25	*Ösenring* copper	98	<0.02	<0.01	<0.01	<0.2
MA-071881	Halle 34:305l, 28	*Ösenring* copper	97	<0.02	<0.01	0.01	<0.2
MA-071882	Halle 34:305l, 5	*Ösenring* copper	97	<0.02	<0.01	<0.01	<0.2
MA-071883	Halle 34:305l, 18	*Ösenring* copper	97	<0.02	<0.01	0.01	<0.2
MA-071887	Halle 34:305l, 30	*Ösenring* copper	97	<0.02	<0.01	<0.01	<0.2
MA-071890	Halle 34:305l, 27	*Ösenring* copper	97	<0.02	<0.01	<0.01	<0.2
MA-071899	Halle 34:305e, 08	*Ösenring* copper	97	0.02	0.01	0.01	0.2
Average			**97**	**0.02**			
2SD			**1**	**0.00**			
MA-071653	Halle 34:305k	Arsenical copper	94	<0.02	<0.01	<0.01	<0.2
MA-071863	Halle 34:305l, 1	Low-impurity copper	99	<0.02	<0.01	0.02	<0.2

Tab. 2 Chemical composition of the Halle-Kanena III objects analysed with energy-dispersive X-ray fluorescence spectrometry and grouped by copper type. Individual values, averages, and standard deviations are given in mass%.

Tab. 2 *Chemische Zusammensetzung der Objekte aus Depot III von Halle-Kanena; Analyse mithilfe von energiedispersiver Röntgenfluoreszenzspektroskopie; Gruppierung nach Kupferart. Einzelwerte, Durchschnittswerte und Standardabweichungen sind in Massenprozent angegeben.*

which have often been regarded as its trade form (i.e., ingots) in the EBA (Butler 1979). However, this interpretation has been challenged because copper of this composition mainly occurs in the form of *Ösenrings* and rarely in finished objects (Krause/Pernicka 1998; Krause 2003). Despite expectations of a lower preservation rate for intermediate technical products, it turns out that among approximately 3000 analysed Bronze Age copper objects with this peculiar composition, two-thirds are *Ösenrings*. This finding greatly reduces the likelihood that these objects functioned as ingots. Instead, there is ongoing debate about whether they had religious significance or served as some kind of pre-monetary means of payment and accumulation of wealth[13]. However, in terms of the elemental composition, the *Ösenrings* of Halle-Kanena III are somewhat exceptional as they resemble, compositionally, the fifteen axes and the spiral arm ring in the hoard, all consisting of nickel-poor fahlore copper (Tab. 2; Fig. 8). Generally, the concentrations of arsenic and antimony are balanced (ratio c. 1) in the analysed objects, ranging both from 0.4 % to 2.1 %. In comparison to the nickel-rich fahlore copper type in the hoard (means 0.78 ± 0.93 % As and 2.3 ± 2.4 % Sb), the levels of arsenic are higher (mean 1.0 ± 0.9 %), while antimony is significantly lower (mean 0.93 ± 0.84 %). The arsenic/antimony ratio for the *Ösenring* copper of c. 1 thus indicates a larger proportion of tennantite in the smelted ore charges than in those for the nickel-rich fahlore copper. Also striking are the absence of lead and the bismuth concentrations of up to 0.06 % (mean 0.02 ± 0.03 %), further distinguishing the items from those of the other copper types in the hoard. With the bismuth detected, the Halle-Kanena III *Ösenring* copper is also slightly different from the classical *Ösenring* copper, which has a median of 0.15 % bismuth in almost 4000 analysed objects from the SAM project[14] (Krause 2003), and a smaller set of *Ösenrings* analysed by E. Lauermann and E. Pernicka (2013). In the following we will call this type of copper nevertheless *Ösenring* copper due to the otherwise very similar chemical composition. Regarding tin, the majority of objects from Halle-Kanena III have values below the detection limit of the EDXRF method used (0.005 %), while only one axe (MA-071899) has a low tin content of 0.3 %. In this context, the *Ösenring* copper in the hoard aligns with the broader pattern of the copper type within the Únětice artefacts, which are either free of tin or have 2–8 % (cf. Berger et al. in prep.).

13 Lenerz-de Wilde 1995; Billig 2000; Junk et al. 2001; Krause 2003; Höppner et al. 2005; Lauermann/Pernicka 2013; Hensler 2019.

14 SAM = Project »Studien zu den Anfängen der Metallurgie« with over 22 000 analyses of metal objects using atomic emission spectroscopy.

As%	Se%	Ag%	Sn%	Sb%	Te%	Au%	Pb%	Bi%
0.50	<0.005	1.09	<0.005	2.13	<0.005	<0.01	<0.01	0.05
1.06	<0.005	1.00	<0.005	1.82	<0.005	<0.01	<0.01	0.05
1.81	<0.005	1.04	<0.005	0.83	<0.005	<0.01	<0.01	0.01
0.84	<0.005	0.97	<0.005	1.07	<0.005	<0.01	<0.01	0.06
1.04	<0.005	1.06	<0.005	0.82	<0.005	<0.01	<0.01	0.01
1.03	<0.005	1.11	<0.005	0.81	<0.005	<0.01	<0.01	0.02
1.13	<0.005	1.02	<0.005	0.66	<0.005	<0.01	<0.01	0.01
0.72	<0.005	0.93	<0.005	0.75	<0.005	<0.01	<0.01	<0.01
0.89	<0.005	1.17	<0.005	0.57	<0.005	<0.01	<0.01	<0.01
0.78	<0.005	1.02	<0.005	0.73	<0.005	<0.01	<0.01	<0.01
2.13	<0.005	1.05	<0.005	1.11	<0.005	<0.01	<0.01	0.05
0.46	<0.005	0.97	<0.005	0.43	<0.005	<0.01	<0.01	<0.01
0.80	<0.005	1.02	<0.005	0.91	<0.005	<0.01	<0.01	0.03
0.75	<0.005	1.17	<0.005	1.04	<0.005	<0.01	<0.01	0.01
0.72	<0.005	0.93	<0.005	0.92	<0.005	<0.01	<0.01	0.01
1.14	<0.005	1.21	<0.005	0.90	<0.005	<0.01	<0.01	0.02
1.12	<0.005	1.01	<0.005	0.79	<0.005	<0.01	0.04	<0.01
0.55	<0.005	1.09	0.29	0.93	0.005	<0.01	0.01	0.01
1.00		**1.02**		**0.96**				**0.02**
0.85		**0.26**		**0.84**				**0.03**
4.9	<0.005	0.055	0.013	0.59	<0.005	<0.01	0.05	0.03
0.010	<0.005	0.092	<0.005	0.51	<0.005	<0.01	0.01	0.01

The fahlore copper with variable nickel served for a majority of 26 axes in the hoard (Tab. 2). Other artefacts, at least within the context of Halle-Kanena III, were not made from this particular copper type. The concentrations of copper impurities fall within the same range as those of the other artefacts, with arsenic averaging to 0.58 ± 0.46 % (0.3–1.9 %) and silver to 1.05 ± 0.17 % (0.9–1.3 %). The mean antimony content of 0.82 ± 0.17 % is lower than the means of the other two types, but the values of the individual artefacts (0.6–1.3 %) still overlap with their respective ranges (Fig. 8b). Nickel concentrations are by definition highly variable (from 0.02 to 0.76 %) and most strikingly show the above-mentioned parallel trend when assessed along with the silver concentrations (Fig. 8a). As such, the data of the axes' copper positions itself exactly between the high and low nickel concentrations in the artefacts of the other copper types. The same applies to cobalt and bismuth, both of which are either below or slightly above the detection limits of the EDXRF (0.01 %). Tin was also detected, but while one set of the objects has low tin concentrations from 0.01 % to 0.2 %, another set is devoid of tin (Tab. 2).

Differences among the various copper types are also evident in the isotopic composition of lead and copper (Tab. 3). The nickel-rich objects in the hoard are characterised by consistently high copper isotope values (δ^{65}Cu) ranging from 0.13 ‰ to 0.61 ‰ (mean 0.40 ± 0.33 ‰), with the massive rings displaying the highest values (Fig. 9). Lead isotope ratios form a dense cluster between 18.39 to 18.44 ^{206}Pb/^{204}Pb, 15.67 to 15.68 ^{207}Pb/^{204}Pb, and 38.56 to 38.59 ^{208}Pb/^{204}Pb, from which only two objects deviate (Fig. 10). Except for one of these outliers with considerably lower ratios (MA-071669), all objects fit well into the existing data for nickel-rich artefacts of the Circum-Harz group from the FOR 550 project (Niederschlag et al. 2003; Frotzscher 2012; Berger et al. in prep.), as is also the case with copper isotopes (Fig. 9a). δ^{65}Cu values are significantly lower for the artefacts of *Ösenring* copper and concentrate around zero (mean 0.01 ± 0.17 ‰). Their lead isotope ratios show a larger variation compared with those of the other copper type, ranging between 18.39 to 18.73 ^{206}Pb/^{204}Pb, 15.66 to 15.69 ^{207}Pb/^{204}Pb, and 38.45 to 38.68 ^{208}Pb/^{204}Pb. The lead isotope composition is similar for the axes from copper with variable nickel, but pieces having low tin concentrations form a short but straight line in ^{206}Pb/^{204}Pb versus ^{207}Pb/^{204}Pb or a tight cluster in ^{206}Pb/^{204}Pb versus ^{208}Pb/^{204}Pb. With -0.04 ‰ to 0.22 ‰ δ^{65}Cu (mean 0.08 ± 0.15 ‰), copper isotope values for these axes and the pieces without tin fall between those of the other two copper types, reflecting a general feature of the variable nickel copper type. However, there is partial overlap at both ends, which is larger with the *Ösenring* copper (Fig. 9a).

Tin isotope values are available for three axes and three arm rings (Tab. 4). The latter have nearly identical tin isotope composition of 0.093 ‰ to 0.099 ‰·u^{-1} δSn, underscoring the close relationship of the tin used. In contrast, one axe crafted from the same nickel-rich copper exhibits a slightly higher δSn value of 0.108 ‰·u^{-1}, while another two of *Ösenring* and variable nickel copper share lower but identical δSn values of 0.081 ‰ and 0.082 ‰·u^{-1}.

Sample no.	Inventory no.	Copper type	$^{208}Pb/^{206}Pb$	2SD	$^{207}Pb/^{206}Pb$
MA-071669	Halle 34:305d	Nickel-rich copper (with Sn)	2.1082	0.0001	0.86030
MA-071672	Halle 34:305n	Nickel-rich copper (with Sn)	2.0944	0.0001	0.85213
MA-071673	Halle 34:305f	Nickel-rich copper (with Sn)	2.0899	0.0001	0.84982
MA-071675	Halle 34:305g	Nickel-rich copper (with Sn)	2.0860	0.0002	0.84748
MA-071706	Halle 34:305h	Nickel-rich copper	2.0939	0.0003	0.85105
MA-071782	Halle 34:305o, 09	Nickel-rich copper	2.0932	0.0001	0.85103
MA-071784	Halle 34:305l, 04	Nickel-rich copper	2.0966	–	0.85227
MA-071833	Halle 34:305o, 10	Nickel-rich copper	n. a.		n. a.
MA-071864	Halle 34:305o, 1	Nickel-rich copper	2.0948	–	0.85150
MA-071867	Halle 34:305l, 21	Nickel-rich copper	n. a.		n. a.
MA-071895	Halle 34:305l, 36	Nickel-rich copper	n. a.		n. a.
MA-071783	Halle 34:305l, 31	Variable nickel copper, Group I	2.0961	–	0.85247
MA-071832	Halle 34:305l, 11	Variable nickel copper, Group I	2.0880	–	0.84832
MA-071877	Halle 34:305l, 10	Variable nickel copper, Group I	n. a.		n. a.
MA-071884	Halle 34:305o, 3	Variable nickel copper, Group I	2.0927	0.0003	0.85069
MA-071886	Halle 34:305o, 5	Variable nickel copper, Group I	2.0926	0.0004	0.85144
MA-071888	Halle 34:305l, 7	Variable nickel copper, Group I	2.0847	0.0001	0.84693
MA-071892	Halle 34:305l, 19	Variable nickel copper, Group I	2.0808	0.0001	0.84494
MA-071894	Halle 34:305l, 6	Variable nickel copper, Group I	2.0742	0.0001	0.84138
MA-071897	Halle 34:305l, 29	Variable nickel copper, Group I	2.0869	0.0001	0.84892
MA-071861	Halle 34:305o, 4	Variable nickel copper, Group II	n. a.		n. a.
MA-071865	Halle 34:305l, 12	Variable nickel copper, Group II	2.0930	0.0001	0.85131
MA-071866	Halle 34:305l, 2	Variable nickel copper, Group II	n. a.		n. a.
MA-071868	Halle 34:305l, 23	Variable nickel copper, Group II	n. a.		n. a.
MA-071872	Halle 34:305l, 34	Variable nickel copper, Group II	2.0921	0.0001	0.85116
MA-071885	Halle 34:305l, 9	Variable nickel copper, Group II	n. a.		n. a.
MA-071889	Halle 34:305o, 7	Variable nickel copper, Group II	2.0898	0.0001	0.84925
MA-071891	Halle 34:305l, 26	Variable nickel copper, Group II	2.0926	0.0001	0.85167
MA-071893	Halle 34:305l, 13	Variable nickel copper, Group II	2.0934	0.0003	0.85086
MA-071896	Halle 34:305e, 22	Variable nickel copper, Group II	2.0948	0.0001	0.85194
MA-071900	Halle 34:305l, 16	Variable nickel copper, Group II	2.0925	0.0001	0.85145
MA-071668	Halle 34:305b	*Ösenring* copper	2.0637	0.0010	0.83645
MA-071670	Halle 34:305m	*Ösenring* copper	2.0761	0.0003	0.84259
MA-071671	Halle 34:305c	*Ösenring* copper	2.0900	0.0004	0.84937
MA-071780	Halle 34:305l, 33	*Ösenring* copper	2.0740	–	0.84146
MA-071781	Halle 34:305l, 03	*Ösenring* copper	2.0880	–	0.84842
MA-071834	Halle 34:305l, 15	*Ösenring* copper	2.0825	–	0.84580
MA-071869	Halle 34:305l, 14	*Ösenring* copper	2.0711	0.0001	0.84017
MA-071871	Halle 34:305l, 32	*Ösenring* copper	2.0858	0.0006	0.84787
MA-071873	Halle 34:305l, 35	*Ösenring* copper	2.0810	0.0010	0.84510
MA-071880	Halle 34:305l, 25	*Ösenring* copper	2.0840	0.0001	0.84734
MA-071881	Halle 34:305l, 28	*Ösenring* copper	2.0707	0.0001	0.84142
MA-071882	Halle 34:305l, 5	*Ösenring* copper	2.0739	0.0001	0.84112
MA-071883	Halle 34:305l, 18	*Ösenring* copper	2.0813	0.0001	0.84602
MA-071890	Halle 34:305l, 27	*Ösenring* copper	2.0905	0.0001	0.85146
MA-071899	Halle 34:305e, 08	*Ösenring* copper	2.0762	0.0001	0.84173
MA-071653	Halle 34:305k	Arsenical copper	2.1154	0.0001	0.86371
MA-071863	Halle 34:305l, 1	Low-impurity copper	2.0858	0.0001	0.84741

Tab. 3 Lead isotope ratios and copper isotope values of the objects from Halle-Kanena III categorised by copper type; »n. a.« means not analysed.

Tab. 3 *Bleiisotopenverhältnisse und Kupferisotopenwerte der Objekte aus Depot III von Halle-Kanena, gruppiert nach Kupferart; »n. a.« steht für nicht analysiert.*

2SD	$^{206}Pb/^{204}Pb$	2SD	$^{207}Pb/^{204}Pb$	2SD	$^{208}Pb/^{204}Pb$	2SD	$\delta^{65}Cu$ ‰	2SD
0.00001	18.153	0.001	15.617	0.001	38.270	0.006	0.60	0.02
0.00001	18.398	0.001	15.677	0.001	38.532	0.002	0.50	0.01
0.00001	18.444	0.001	15.674	0.001	38.545	0.005	0.58	0.01
0.00007	18.525	0.007	15.700	0.007	38.643	0.019	n. a.	–
0.00010	18.428	0.004	15.683	0.001	38.586	0.006	n. a.	–
0.00001	18.415	0.001	15.671	0.001	38.545	0.003	0.27	0.01
–	18.393	–	15.676	–	38.563	–	0.33	0.01
	n. a.		n. a.		n. a.		0.49	0.01
–	18.417	–	15.682	–	38.581	–	0.46	0.003
	n. a.		n. a.		n. a.		0.13	0.09
	n. a.		n. a.		n. a.		0.24	0.01
–	18.368	–	15.658	–	38.501	–	n. a.	–
–	18.484	–	15.680	–	38.595	–	n. a.	–
	n. a.		n. a.		n. a.		0.01	0.004
0.00011	18.436	0.008	15.683	0.007	38.581	0.011	n. a.	–
0.00008	18.381	0.014	15.650	0.011	38.464	0.022	n. a.	–
0.00006	18.502	0.014	15.670	0.013	38.571	0.033	0.05	0.02
0.00001	18.567	0.001	15.688	0.001	38.635	0.002	n. a.	–
0.00001	18.641	0.001	15.684	0.001	38.666	0.001	0.01	0.02
0.00001	18.454	0.001	15.666	0.001	38.512	0.001	n. a.	–
	n. a.		n. a.		n. a.		0.03	0.01
0.00008	18.414	0.001	15.676	0.001	38.541	0.001	0.12	0.01
	n. a.		n. a.		n. a.		0.02	0.01
	n. a.		n. a.		n. a.		–0.04	0.001
0.00001	18.414	0.001	15.673	0.001	38.524	0.002	0.12	0.01
	n. a.		n. a.		n. a.		0.08	0.02
0.00007	18.462	0.014	15.679	0.011	38.582	0.028	0.14	0.01
0.00001	18.408	0.001	15.677	0.001	38.521	0.001	0.01	0.01
0.00008	18.416	0.012	15.669	0.001	38.552	0.022	0.22	0.01
0.00001	18.400	0.001	15.676	0.001	38.545	0.001	0.18	0.01
0.00001	18.413	0.001	15.678	0.001	38.529	0.002	0.13	0.004
0.00008	18.730	0.062	15.667	0.052	38.653	0.122	n. a.	–
0.00004	18.610	0.007	15.681	0.007	38.636	0.021	–0.01	0.01
0.00017	18.436	0.006	15.659	0.007	38.531	0.020	n. a.	–
–	18.623	–	15.671	–	38.624	–	n. a.	–
–	18.476	–	15.675	–	38.578	–	n. a.	–
–	18.551	–	15.690	–	38.632	–	n. a.	–
0.00001	18.660	0.001	15.677	0.002	38.645	0.005	–0.01	0.004
0.00003	18.504	0.003	15.689	0.003	38.596	0.010	0.04	0.02
0.00010	18.540	0.010	15.670	0.010	38.580	0.010	–0.18	0.01
0.00001	18.490	0.001	15.667	0.001	38.532	0.002	n. a.	–
0.00002	18.636	0.001	15.68	0.001	38.588	0.002	0.08	0.01
0.00001	18.651	0.001	15.688	0.001	38.681	0.003	0.08	0.002
0.00001	18.528	0.001	15.675	0.001	38.563	0.001	n. a.	–
0.00001	18.392	0.001	15.660	0.001	38.448	0.001	0.02	0.03
0.00001	18.634	0.001	15.685	0.001	38.688	0.001	0.02	0.01
0.00003	18.119	0.001	15.650	0.001	38.329	0.004	n. a.	–
0.00005	18.499	0.001	15.676	0.001	38.585	0.001	0.68	0.01

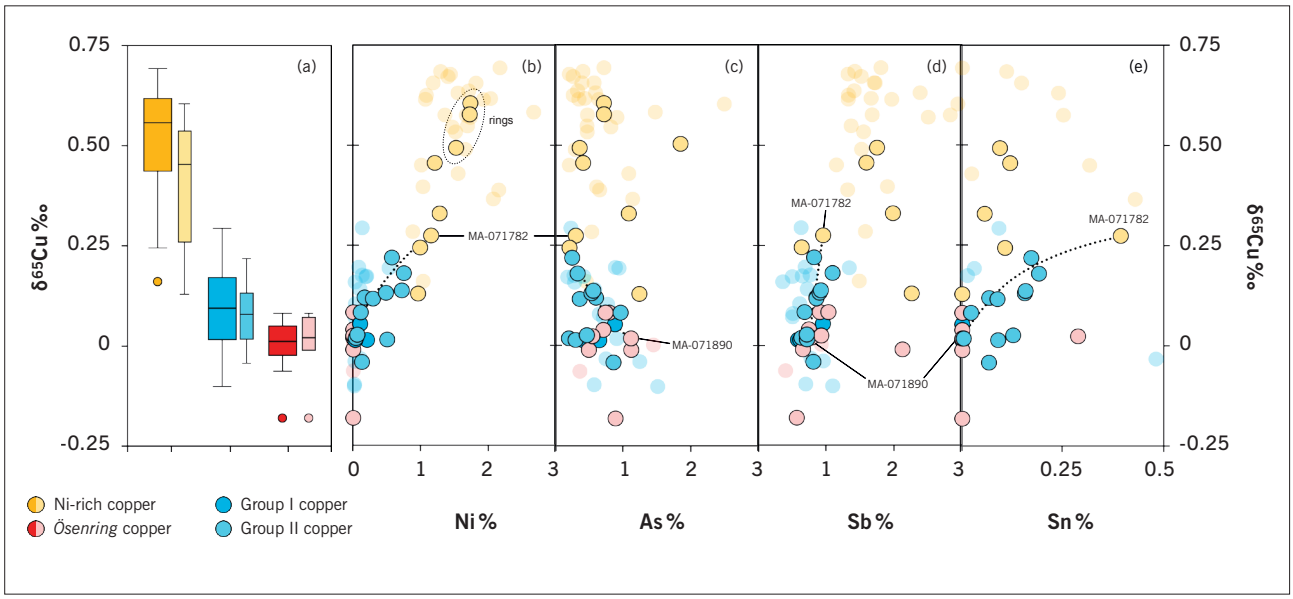

Fig. 9a–e Copper isotope composition (δ^{65}Cu) versus concentrations of nickel, arsenic, antimony, and tin of metal objects from the Halle-Kanena III hoard (b–e). The data exhibits mixing lines (dotted lines) for the Group II axes with variable nickel concentrations when the axes MA-071782 (nickel-rich copper) and MA-071890 (*Österring* copper) are considered as representatives for the starting materials. In (a) the copper isotope variation of the respective copper types in the hoard (narrow boxplots) is compared with that of the copper of the entire Circum-Harz group (wide boxplots).

Abb. 9a–e *Kupferisotopenzusammensetzung (δ^{65}Cu) im Vergleich zur Nickel-, Arsen-, Antimon- und Zinnkonzentration von Metallobjekten aus Depot III von Halle-Kanena (b–e). Die Daten weisen für die Beile der Gruppe II mit variablen Nickelkonzentrationen Mischungslinien auf (gepunktete Linien), wobei die Beile MA-071782 (nickelreiches Kupfer) und MA-071890 (Österingkupfer) als stellvertretend für die Ausgangsmaterialien angesehen werden. (a) vergleicht die Kupferisotopenvariation der jeweiligen Kupferarten des Depotfunds (schmaler Kastenplot) mit derjenigen des Kupfers der gesamten Circumharzer Gruppe (breiter Kastenplot).*

Mixing

The most peculiar feature of the artefacts in the Halle-Kanena III hoard is the very specific silver concentration of close to 1 % for the three main copper types. In a diagram of silver versus nickel, the data plots along a line parallel to the y-axis, which prompted Lockhoff et al. (2019) to the hypothesis of copper mixing by the Únětice metallurgists. If the anthropogenic mixing hypothesis by the authors were true, it would imply the need to mix a copper type high in nickel with a specific silver content of approximately 1 % with another copper type lacking nickel but having similar silver levels. Without this combination, the parallel alignment of data from the copper type with variable nickel in the Ag-Ni diagram would not be observed (Fig. 8a). Mixing two copper types with variable nickel and silver contents would result in oblique lines (Fig. 11a). Conversely, if a natural explanation were applicable, it would entail the smelting of copper ores containing fahlore minerals with constant silver/copper ratios and highly variable nickel concentrations. Since fahlore minerals do not accommodate nickel in their crystal lattice, it must be assumed that nickel was part of accompanying minerals of the argentiferous copper ores such as gersdorffite (NiAsS), nickeline (NiAs), and millerite (NiS)[15]. Because the ratio of copper and silver does not significantly change during smelting, whatever process may have been used (Tylecote et al. 1977; Pernicka 1999), it is entirely conceivable that copper metal with a consistent content of about 1 % silver is obtained, if the silver derives only from fahlore minerals. On the other hand, since nickel resides in accessory minerals, the amount of which may vary from ore charge to ore charge, the copper produced would contain variable nickel concentrations. In this scenario, it is even possible to produce fahlore copper with or without nickel, assuming that different parts of a mine or deposit were used for copper production.

Mixing of metals

The main question now is whether the two hypotheses above can be distinguished with the enlarged set of chemical and isotopic data. A total of 61 objects of various kinds were buried in Halle-Kanena III, including 48 flanged axes. All three copper types are present in the hoard, supplemented by arsenical and low-impurity copper used for one halberd and one of the axes, which are both left aside here. The copper with varying nickel was exclusively employed for axes, while the *Östering* copper is represented by axes, an arm spiral, and *Österings*. The nickel-rich fahlore copper, in turn, was used for the production of axes, arm spirals, and massive open rings. With the exception of the five massive rings, all objects contain either very low tin concentrations or no tin at all. This particularly holds true for

15 Martinek/Sydow 2004; Lutz 2016; Tropper et al. 2019; Biagioni et al. 2020.

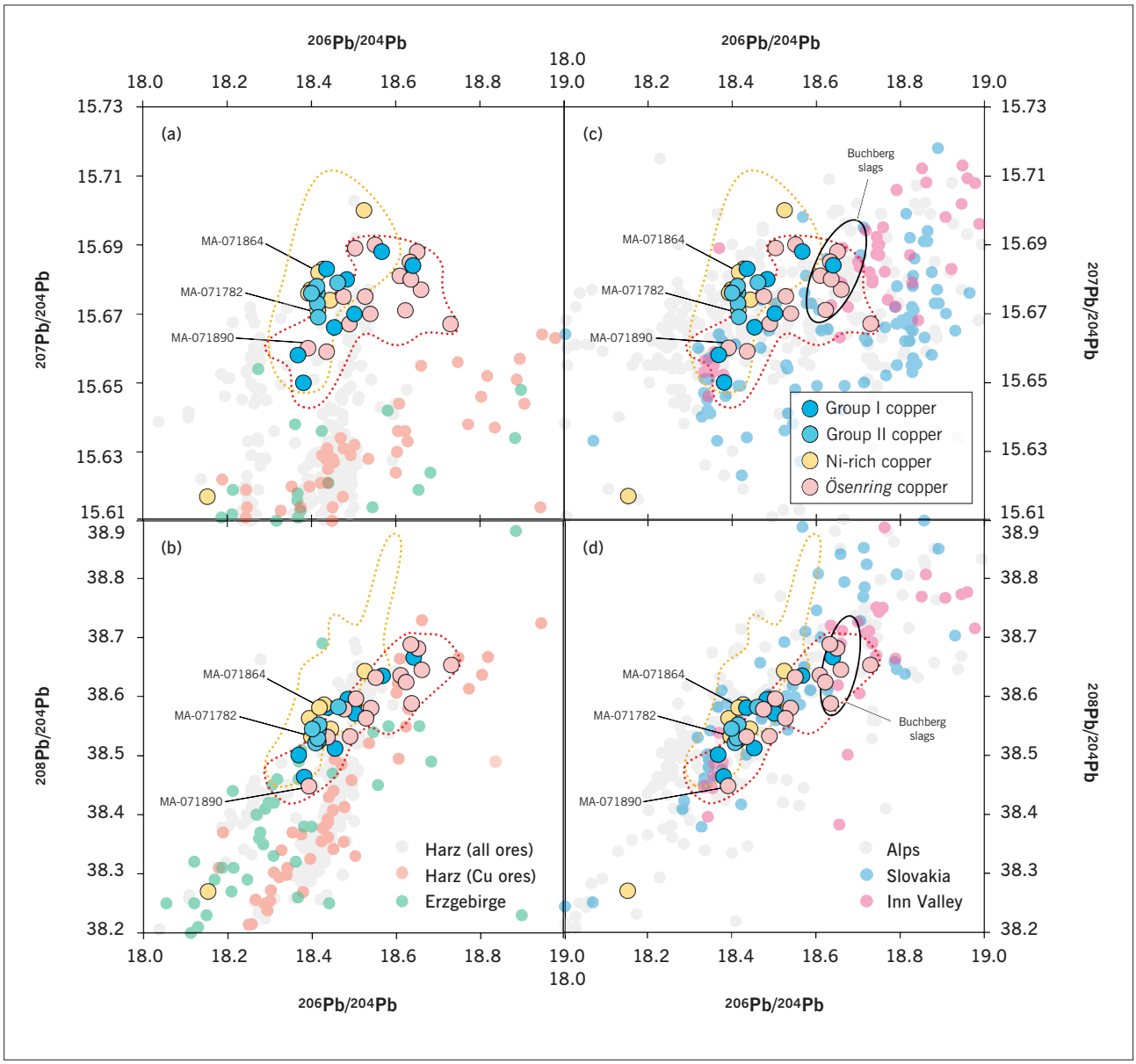

Fig. 10a–d Lead isotope ratios of the Halle-Kanena III objects compared to all analysed artefacts from the Circum-Harz group from nickel-rich copper (orange-dotted shape) and *Ösenring* copper (red-dotted shape). Also shown are the lead isotope ratios of copper ores from the Harz Mountains, the Erzgebirge, the Inn Valley with the Buchberg smelting slags, and the Slovakian Ore Mountains, as well as entire data from the Harz and the Alps (in grey).

Abb. 10a–d *Bleiisotopenverhältnisse der Objekte aus Depot III von Halle-Kanena im Vergleich zu sämtlichen analysierten Artefakten der Circumharzer Gruppe aus nickelreichem Kupfer (Bereich mit orange gepunkteter Umrandung) und Ösenringkupfer (Bereich mit rot gepunkteter Umrandung). Ebenfalls dargestellt sind die Bleiisotopenverhältnisse von Kupfererzen aus dem Harz, dem Erzgebirge, dem Inntal mit den Verhüttungsschlacken aus Buchberg und dem Slowakischen Erzgebirge sowie sämtliche Daten aus dem Harz und den Alpen (grau).*

Sample no.	Inventory no.	Copper type	δSn ‰·u^{-1}	2SD	δSn$_{korr}$ ‰·u^{-1}	2SD
MA-071669	Halle 34:305d	Nickel-rich copper (with Sn)	0.098	0.001	0.073	0.001
MA-071672	Halle 34:305n	Nickel-rich copper (with Sn)	0.099	0.002	0.074	0.002
MA-071673	Halle 34:305f	Nickel-rich copper (with Sn)	0.093	0.001	0.068	0.001
MA-071864	Halle 34:305o, 1	Nickel-rich copper	0.108	0.006	0.083	0.006
MA-071896	Halle 34:305e, 22	Variable nickel copper, Group II	0.081	0.003	0.056	0.003
MA-071899	Halle 34:305e, 08	*Ösenring* copper	0.082	0.002	0.057	0.002

Tab. 4 Measured and fractionation-corrected tin isotope values of the objects from Halle-Kanena III. For the method of correction see Berger et al. 2018 and Berger et al. 2022a.

Tab. 4 *Gemessene und fraktionierungskorrigierte Zinnisotopenwerte der Objekte aus Depot III von Halle-Kanena. Zur Korrekturmethode siehe Berger et al. 2018 und Berger et al. 2022a.*

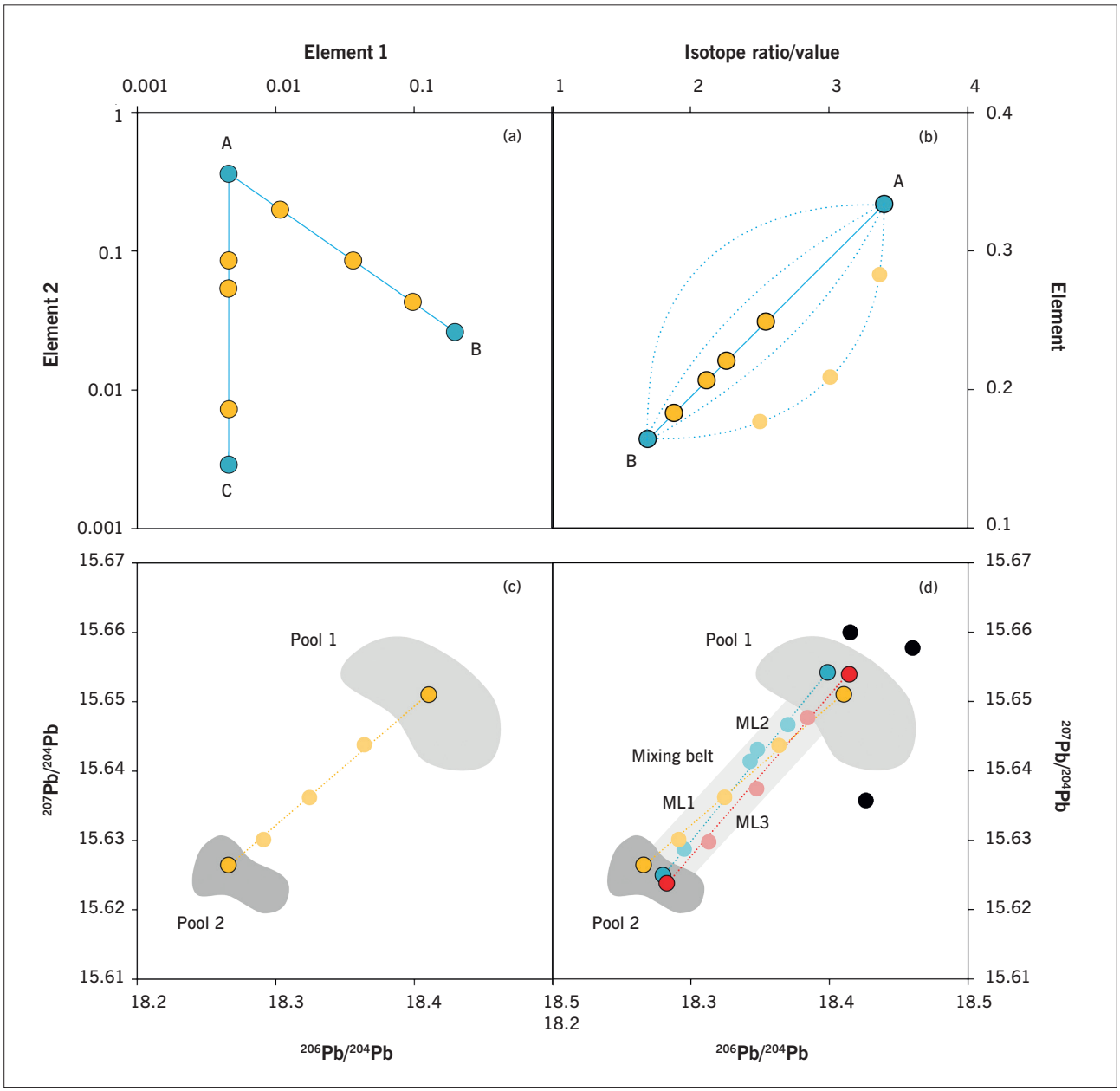

Fig. 11a–d Theoretical principles of metal mixing with two components and their impact on the analytical data. (a) shows mixing of two starting materials A and B having different elemental compositions, while the concentration of element 1 is the same for materials A and C. The result is oblique or parallel mixing lines with all mixtures (orange) in between. When isotope ratios are considered (b), the mixing lines can become curved, the degree of which depends on the differences in the concentration of the considered elements. (c) and (d) show the isotopic composition of two pools of metal, from which in (c) one batch of pool 1 is mixed with one batch of pool 2 in different proportions. In (d) further batches from each pool with slightly differing compositions are mixed, leading to comparable but not identical mixing lines (ML). There is an overall trend towards more dispersed data points located within a mixing belt (grey bar). The variously coloured points are not directly related to a single mixing procedure but indirectly through the same pools of the original metals.

Abb. 11a–d *Theoretische Grundlagen des Metallmischens mit zwei Komponenten und der Effekt auf die Analysedaten. (a) Mischen zweier Ausgangsmaterialien A und B mit unterschiedlicher Elementzusammensetzung, wobei der Anteil von Element 1 für A und C identisch ist. Daraus ergeben sich schräge oder parallele Mischungslinien mit allen Mischungen (orange) dazwischen. (b) Bei Einbeziehung der Isotopenverhältnisse können sich die Mischungslinien krümmen. Der Krümmungsgrad hängt von den Unterschieden der Anteile der betrachteten Elemente ab. (c–d) Isotopenzusammensetzung zweier Vorräte von Metall. In (c) wird eine Charge aus Vorrat 1 mit einer Charge aus Vorrat 2 in unterschiedlichen Verhältnissen gemischt. In (d) werden weitere Chargen aus jeder der Vorräte mit leicht unterschiedlichen Zusammensetzungen gemischt, sodass sich vergleichbare, aber nicht identische Mischungslinien (ML) ergeben. Insgesamt ist ein Trend hin zu weiter gestreuten Datenpunkten innerhalb eines Mischbereichs (grauer Balken) zu erkennen. Die verschiedenfarbigen Punkte sind nicht direkt durch einen einzelnen Mischvorgang miteinander verbunden, sondern indirekt, indem ihre Ausgangsmaterialien aus denselben Vorräten stammen.*

the axes of variable nickel copper, half of which (15 pieces) are tin-free, the other half (11 pieces) having low tin concentrations of up to 0.2 % (Tab. 2). Thus, it seems that there are two subgroups of copper with variable nickel – one without (Group I) and one with low tin (Group II).

Concerning the possibility of metal mixing, it is noteworthy that there is a positive correlation between tin and nickel in the Group II artefacts with low tin. The trend ranges from data of the nickel-rich artefacts with tin in the hoard to the data of the objects of *Ösenring* copper, which virtually con-

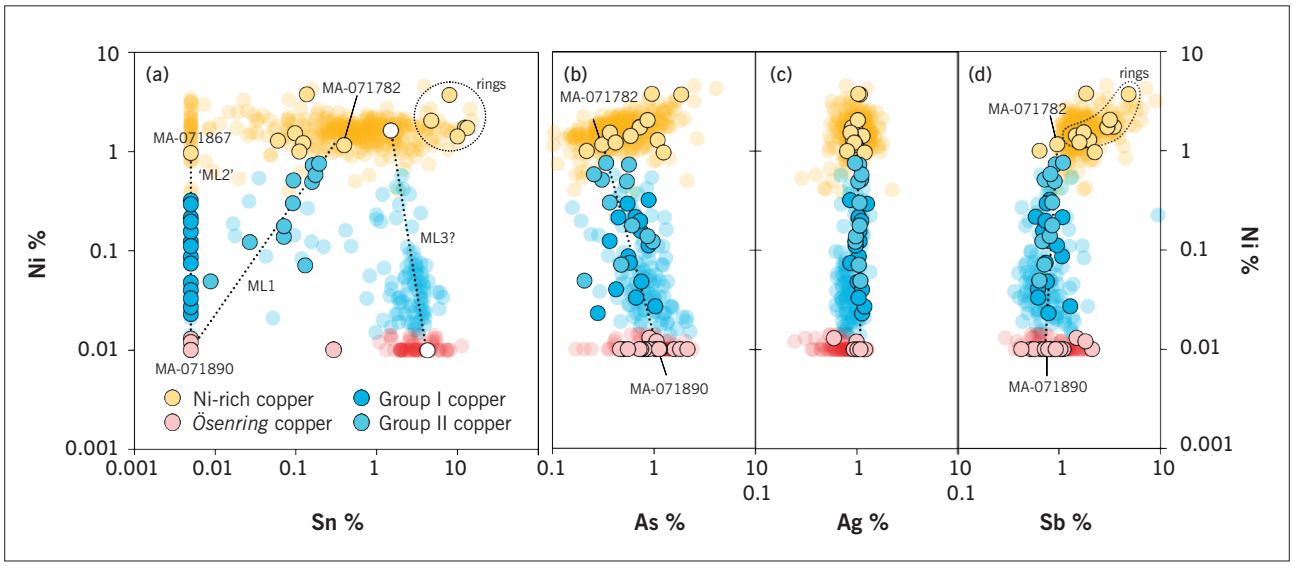

Fig. 12a–d Bi-variate diagrams of the chemical composition of the Halle-Kanena III hoard with putative mixing lines (ML, black dotted lines). Semi-transparent data points are from other Únětice artefacts analysed during FMZM and FOR 550 projects, the colours of which correspond to that of Halle-Kanena III. Note that the axes MA-071782 and MA-071890 from ML1 could be the end members of the mixing lines in all element combinations. ›ML2‹ with end member MA-071867 is only theoretical as the perfect line is based on the limit of determination of tin by EDXRF (0.005 %). ML3 is not related with material from Halle-Kanena III, but represents a possible mixing of Únětice *Ösenring* and nickel-rich copper with higher tin contents.

Abb. 12a–d *Bivariate Diagramme der chemischen Zusammensetzung des Depots III von Halle-Kanena mit den mutmaßlichen Mischungslinien (ML, schwarz gepunktete Linien). Die halbtransparenten Datenpunkte stammen von anderen Aunjetitzer Artefakten, die im Zuge der Projekte FMZM und FOR 550 untersucht wurden. Ihre Farben entsprechen denen der Kupfersorten von Depot III von Halle-Kanena. Man beachte, dass die Beile MA-071782 und MA-071890 aus ML1 die Endglieder der Mischungslinien in sämtlichen Elementkombinationen sein könnten. ›ML2‹ mit dem Endglied MA-071867 ist rein theoretisch, da die perfekte Linie auf der Bestimmungsgrenze für Zinn bei der energiedispersiven Röntgenfluoreszenzspektroskopie beruht (0,005 %). ML3 hat keine Verbindung zum Material von Halle-Kanena III, stellt jedoch die denkbare Mischung von Aunjetitzer Ösenringkupfer und nickelreichem Kupfer mit höheren Zinngehalten dar.*

tain no tin and nickel (Fig. 12a; ML1). The striking correlation of these elements ($R^2 = 0.67$) can be perceived as a mixing line, or rather several parallel mixing lines resembling a mixing belt (cf. Fig. 11d). It serves as robust evidence for mixing two metal bases: one with tin and nickel, and one without the two elements, corresponding to the nickel-rich fahlore and *Ösenring* copper types. Surveying the metalwork of the entire Central German Únětice Culture, the latter copper type is either free of tin or has concentrations exceeding 1 %, whereas the former copper type was found to regularly contain traces or appreciable concentrations of tin. Nevertheless, a substantial quantity of artefacts consisting of nickel-rich fahlore copper lacks tin completely (see Fig. 12a, transparent symbols; Berger et al. in prep.)[16]. One nickel-rich axe in the Halle-Kanena III hoard has also no detectable tin (MA-071867), and, as such, metal of this nature could have served as the starting material for all axes of Group I with variable nickel and without tin, if we also assume mixing with *Ösenring* copper (Fig. 12a, ›ML2‹).

The aforementioned conclusions find support in combinations of other elements. There is a faint positive correlation between nickel and antimony, while a clear negative trend is observed with arsenic (Fig. 12b, d). The latter contradicts the expectation of smelting separate minerals containing either nickel or arsenic, mentioned above, thus this trend follows a mixing line. Furthermore, nickel shows the linear alignment for constant silver (Fig. 12c), but, unlike the other elements, this observation cannot contribute directly to the question of metal mixing. However, the limited variation of 1.05 ± 0.21 % for the Group I objects and 1.04 ± 0.10 % for those of Group II aligns closely with the silver variation in the objects of *Ösenring* (1.02 ± 0.26 %) and nickel-rich fahlore copper (0.98 ± 0.23 %) in the hoard, which is much narrower than the variation in all objects of the Circum-Harz group. The parallel trend thus appears to have two well-defined end members in the chemical clusters of the other two predominant copper types in the hoard, serving as an indirect indicator for mixing. Interestingly, one specific axe of nickel-rich fahlore copper (MA-071782) and a second one of *Ösenring* copper (MA-071890) may serve as representatives for the end points (i.e. the end members) of the putative mixing lines for the Group II artefacts when only the elemental composition is considered (Fig. 12). However, axe MA-071782 itself clearly cannot have been the initial material for mixing in view of its lead isotope ratios (see below and Fig. 10).

The evidence provided by the trend lines of tin, antimony, and arsenic versus nickel (Fig. 12) for mixing of metal is corroborated by the copper isotope composition of the artefacts in the Halle-Kanena III hoard. Each copper type exhibits slightly different averages and data spans (Fig. 9a; see also Lockhoff et al. 2019). On the one hand, the distinctive isotope values for the copper offer insights into the processing

16 See also the metalwork from the Jelšovce cemetery, southwestern Slovakia, with more than 600 burials (Bátora/Pernicka 1999; Krause 2003, table on CD). Altogether, 410 samples of metal objects were analysed, and four major compositional groups were identified with cluster analysis based on the concentrations of arsenic, antimony, nickel, silver, and bismuth. The largest cluster comprised objects of nickel-rich fahlore copper, about half of which contained tin between 0.1 % and 1 %, or no tin. The other half have tin contents above 1 %.

of specific ore minerals, indicating a deliberate selection and exploitation of fahlore deposits by prehistoric miners. This likely involves the homogenisation through beneficiation and the mixing of ore charges leading to lower variations of the specific ore types compared to the generally large span of copper isotope values in ore deposits. On the other hand, it is striking that the δ^{65}Cu signatures of the fahlore copper with variable nickel average to 0.09 ± 0.20 ‰ and concentrate in between the data of the other copper types (Ni-rich: 0.52 ± 0.27 ‰; *Ösenring*: 0 ± 0.15 ‰), despite exhibiting overlap at both ends (Fig. 9a). Additionally, the δ^{65}Cu values correlate with the elemental composition. Robust trend lines effectively connect the clusters of the nickel-rich and the *Ösenring* copper, especially when the nickel contents are considered (Fig. 9b). As discussed earlier in this chapter, the nickel-rich axe MA-071782 and the axe MA-071890 from *Ösenring* copper could serve as anchors for the Group II trend line in the respective copper clusters, between which the majority of the data of Group II are distributed. Comparable trends are seen for tin, antimony, and arsenic, but, as with the chemical composition, data points are more dispersed than for nickel. However, the two above-mentioned axes could still be considered as representatives of the copper originally used for the production of axes with variable nickel contents (Fig. 9c–d).

Unlike the combination of trace element concentrations and copper isotope values, which have so far only rarely been used to identify the mixing of metals (e.g. Berger et al. 2022; Berger et al. 2022a), the combination of trace elements and lead isotope ratios has frequently been applied for this purpose. One can use the two parameter sets separately and search for mixing trends among the same selection of samples (Nørgaard et al. 2021) or use mixed diagrams of element concentrations versus lead isotope ratios. The problem with this approach is that mixtures of two components, having different chemical abundances and isotopic ratios, show up in such plots as curved or so-called hyperbolic mixing lines rather than straight trends (Fig. 11b). But by plotting the inverse concentration of lead (1/Pb) against any isotope ratio of lead, for instance, the mixing trends become linear and thus easier to discern (Pernicka 1987; Pollard/Bray 2015; Berger et al. 2022). However, a linear mixing line is only observed when two definitive end members are mixed. If exclusively the inverse concentration of lead is used in this approach, then the mixing of lead from the assumed end members can be detected. In principle, all elements whose ratios to copper are not much affected by the melting process are suitable for such a consideration, as has been demonstrated in Figure 9 for the combination with copper isotopes. Regardless which data is used – either element/Pb isotope ratios or element/Cu isotope values – the relative position of mixtures on the connecting lines between two end members has to be the same for any considered data. Otherwise, mixing is unlikely.

Basically, the situation of archaeological metal hoards can be considered a more complex affair as it is realistic to assume a number of possible end members from metal pools with a limited range of chemical and lead isotope composition rather than only two discrete starting materials. This stems from the fact that from single metal batches of two pools, for example, only a small number of mixtures can be obtained depending on the size of the objects. This assumption entails that there will always be some scatter along a set of theoretical mixing lines, leading to an overall trend in the form of the above-mentioned mixing belt, but no proper mixing line (Fig. 11c–d). This could make the identification of mixing a challenging task. Transferred to the Halle-Kanena III case, it might well be conceivable, based on the Group II data, that there were several starting materials with slightly differing compositions in the two pools of nickel-rich and *Ösenring* fahlore copper, from which the axes with variable nickel contents were produced through mixing.

Unfortunately, the above approach with lead isotope ratios is not directly applicable to the Halle-Kanena III data set due to the low sensitivity of the employed EDXRF for lead. Many lead values are below the limit of determination (< 0.01 %), making it impossible to use the inverse lead concentrations in combination with the contents of other elements and the lead isotope ratios. Nonetheless, the relative position of data of the Group II axes are at least the same for all lead isotope ratios when they are plotted against the concentration of nickel and other elements (Fig. 13). Thus, the lead isotope composition is principally in line with the above requirements for mixing procedures. Also, as reported earlier, the lead isotope ratios of Group II either show a linear trend or form a tight cluster. The ratios essentially match with those of nickel-rich artefacts of the Únětice Culture, but importantly, they exhibit overlap with only part of the nickel-rich axes and arm rings in the hoard (Fig. 10). This includes axe MA-071782, for which reason it could not have been the immediate starting material for mixing. However, another axe (MA-071864) and the arm spiral (MA-071706) in the hoard have higher $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ lead isotope ratios, and are therefore different from the Group II objects. Both artefacts have isotope signatures that might represent those of the metal (and first end member) used in the presumed mixing procedure (Fig. 10). Conversely, no overlap is observed for Group II with the axes from *Ösenring* copper. However, among all analysed pieces from the hoard, only one axe (MA-071890) has a signature that could potentially conform to the *Ösenring* metal (and second end member) used in mixing. All others distinctly deviate from the location of a theoretical end member (Fig. 10). If this axe (MA-071890) and the other one (MA-071864) do in fact represent the original starting materials for mixing, and if the large differences in the nickel contents of the copper types are taken into account, the curved mixing lines can be delineated between both items in the nickel-lead isotope plot. This line accommodates the majority of Group II axes, as depicted in Figure 13. Consequently, overall, the lead isotope composition of the Group II axes does not contradict the hypothesis of mixing.

The situation becomes notably intricate when considering the axes of Group I. Although aligning well in terms of trace elements (Fig. 12), no common trends are discernible in the lead isotope ratios across all artefacts (Fig. 10). The data points are more scattered compared to those of Group II. Four axes (MA-071832, -84, -92, -94) seem to establish some kind of a trend, extending from the data points of the nickel-rich

artefacts in the hoard towards an agglomeration of points from objects crafted from *Ösenring* copper with higher isotopic signatures (Fig. 10). In contrast, two axes (MA-071883, -86) deviate from this unclear alignment, displaying even lower $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ ratios than one *Ösenring* and one axe (MA-071890) of *Ösenring* copper, concentrating at the less radiogenic part of the diagram. Nonetheless, both objects fall completely within another cluster of data points when involving objects of *Ösenring* copper of the entire Únětice Culture (Fig. 10). Finally, another two axes (MA-071888, -97) stand apart from all observed patterns. Therefore, if we indeed deal with metal mixing also in the case of the axes from Group I, as suggested by the correlations in metal chemistry (see Fig. 12), we must definitely assume the existence of more than one mixing procedure with different starting batches of either copper type to elucidate the data points of the Group I artefacts. However, in contrast to the Group II axes, tin-free copper from one pool of nickel-rich copper might have been mixed with *Ösenring* copper from two or even more pools to produce the axes of Group I.

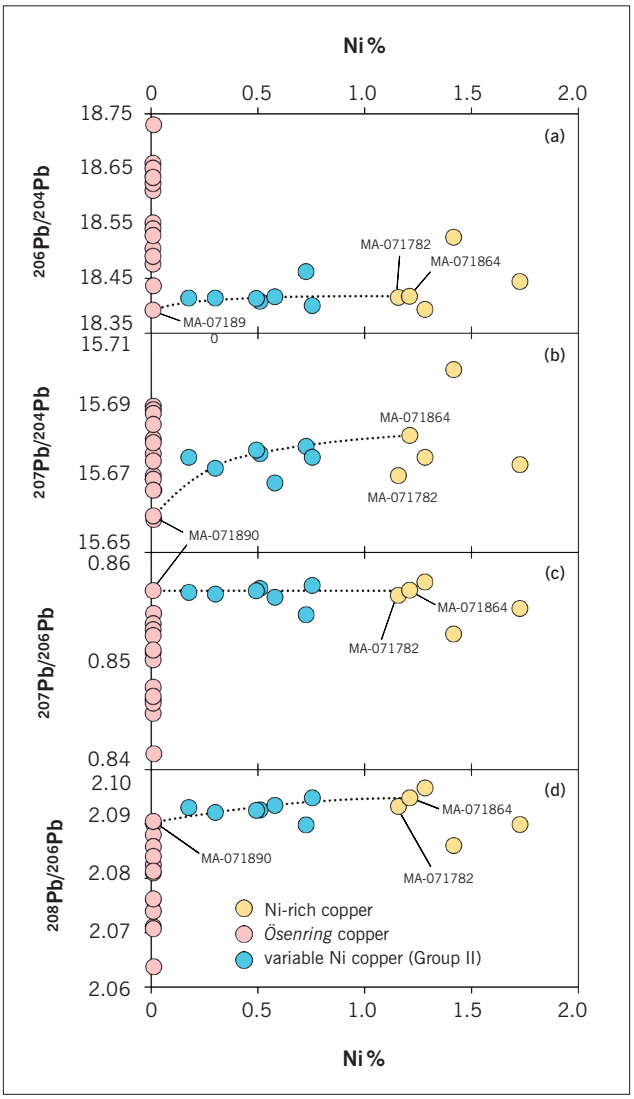

Fig. 13a–d Lead isotope ratios versus nickel concentrations of the Halle-Kanena III objects showing indication for mixing (black-dotted mixing lines). Unlike other combinations of analytical proxies, axe MA-071782 represents no proper end member here due to its lower $^{207}Pb/^{204}Pb$. Instead, axe MA-071864 could serve as end member, even if it is not as compatible in other data.

Abb. 13a–d *Bleiisotopenverhältnisse gegen Nickelgehalt der Objekte aus Halle-Kanena III mit Hinweisen auf Metallmischung (schwarz gepunktete Mischungslinien). Im Gegensatz zu anderen Kombinationen analytischer Proxys stellt Beil MA-071782 aufgrund seines niedrigeren $^{207}Pb/^{204}Pb$-Verhältnisses hier kein Endglied dar. Stattdessen könnte diese Rolle Beil MA-071864 zufallen, auch wenn andere Daten nicht so gut dazu passen.*

Mixing of ores

Instead of mixing different types of metals, it is in principle conceivable that copper ores from various deposits, not to mention various ore types, were mixed and smelted together. This is rather unlikely, though not entirely impossible. Within a geographically limited mining region such as the well-known fahlore district of Schwaz-Brixlegg, Austria, as a possible source region for *Ösenring* copper (Höppner et al. 2005; Lauermann/Pernicka 2013), ore chemistry and mineralogy may vary considerably[17]. If copper ores from that region were processed and smelted at central places, and ores from different mines were smelted there, mixed chemical and isotopic signatures in copper may theoretically emerge. These signatures will be virtually indistinguishable from the patterns through mixing metals.

Assessment of this scenario is mainly restricted to hypothetical considerations, as evidence of smelting places with meaningful metallurgical remains are rare throughout the EBA. One of these places is Buchberg near Wiesing in the Lower Inn Valley, Tyrol, Austria, where slags, technical ceramics, and raw copper from the EBA were found (Martinek/Sydow 2004; Schubert/Pernicka 2013; Keil 2023). Analyses of these metallurgical remains prove that antimony-rich fahlores from the vicinity of Buchberg were processed here. Among some of the most interesting finds, pieces of raw copper and copper casting cakes were excavated, which typically contain arsenic, antimony, silver, and bismuth as the result of smelting ores from the nearby fahlore deposits (Otto/Witter 1952, 204 Nr. 1276; Schubert/Pernicka 2013; Martinek/Sydow 2004). While most of the raw copper is very poor in nickel and compares to *Ösenring* copper, one of the casting cakes contains 4.5 % of it alongside the other elements and cobalt (Martinek 1997; Martinek/Sydow 2004, Tab. 4, Rohmetall 2). This finding corresponds to the nearby smelting site of the Kiechlberg, Tyrol, Austria, where also nickel-rich and *Ösenring*-like raw copper were found side-by-side (Krismer et al. 2013; Lutz 2016, 342). Hence, it seems possible that different types of copper were produced at the same location, and such copper may have been mixed. However, it is equally possible that the differently composed copper reflects the smelting of local primary and secondary ores. The Buchberg site also yielded several pieces of ores, part of which were weathered (malachite,

17 Martinek/Sydow 2004; Schubert/Pernicka 2013; Grutsch et al. 2019; Tropper et al. 2019.

etc.), while others were primary fahlores. There were even ores with intermixed secondary and primary ore minerals. If these naturally mixed ore assemblages were smelted, as Martinek (1997; 2011) suggests, the resulting copper can contain nickel (and cobalt), even though the charges of primary fahlores were nickel-free or -poor (Martinek 1997; Martinek 2011; Martinek/Sydow 2004). The reason is the enrichment of nickel and cobalt in the oxidised ores (e.g., malachite or azurite). This way, nickel as well as cobalt would have entered copper together with other impurities in a natural way, but not intentionally through the directed mixing of ores. An anthropogenic reason would thus not apply, leading back to the initially raised possibility of natural co-incorporation of nickel and silver.

Nonetheless, deliberate mixing of different types of ores cannot principally be excluded in view of numerous casting cakes of fahlore copper from the Late Bronze Age in the Alps and the northern foothills with variable nickel up to 0.1 % (Möslein/Pernicka 2019). Whether these casting cakes are the product of primary smelting or the subsequent mixing of different types of fahlore copper is, however, not entirely clear. Given the very low variation of the silver concentrations in the axes with variable nickel contents, and the similar silver contents in the nickel-rich and *Ösenring* copper in the Halle-Kanena III hoard, a mixing of either ores or raw copper in the source region(s) appears a less likely option. The striking relationships, as indicated by the analytical data together with the few unfinished axes, rather speaks in favour of a mixing of metal and a production of all axes in the Únětice territory.

Some thoughts about the origin of the copper

Even though it is not a primary goal of this article to unravel the origins of the copper of the Halle-Kanena III artefacts, some words must nevertheless be said because they may be crucial for understanding the economic and cultural enmeshments of the Únětice Culture. Before discussing potential copper sources, it must be stressed that tracking the ores of the copper with variable nickel contents is only possible to a limited extent. As argued in this article, this specific copper is the product of mixing two fahlore copper sorts, namely, the nickel-rich copper and the copper of the *Ösenring* type. This finding has bearing to provenance studies, since mixtures of metals may not reflect the origin of the starting materials, especially if more than two pools must be assumed (Fig. 11). However, as shown, in the Halle-Kanena III hoard we are dealing most likely with only two possible metal pools used for mixing, which reduces uncertainties considerably.

In the past 50 years, analytical programs with an archaeological focus revealed that Central Europe was economically and culturally highly interwoven and there were extensive copper distribution networks, into which Central Germany was also integrated[18]. The two main types of metal are not unique to the metallurgy of the Central German Únětice Culture. They also occurred elsewhere in Europe, whereby fahlore copper with nickel (commonly called ›Singen copper‹) enjoyed by far the largest distribution from the Carpathians over the entire Alpine region and Central Europe to Denmark, even including southern France (Junghans et al. 1968; Krause 2003). The classical *Ösenring* copper enjoyed a wide distribution, too, but shows a pronounced occurrence in the eastern Alpine Piedmont and in eastern Central Europe, especially Moravia (Junghans et al. 1968; Krause/Pernicka 1998a; Krause 2003). That is why the copper sources for this latter copper type are mainly sought in eastern regions. Chemical and lead isotope analyses of objects from *Ösenring* copper support this view, and, based on comparison with fahlores, the large copper deposits of the Schwaz-Brixlegg district in the Lower Inn Valley are most often regarded as the source region for the fahlore copper without nickel[19]. Statements about the specific origin of the *Ösenring* copper type are nevertheless challenging because its lead isotope ratios are generally highly variable, despite its rather uniform chemical composition. Moreover, the Inn Valley shows partial isotopic and chemical overlap with fahlores from other regions, such as the western Alps and the Slovakian Ore Mountains (Berger et al. in prep.).

The Únětice artefacts from the Circum-Harz group, consisting of *Ösenring*-type copper, and the chemically similar *Ösenrings* and axes in hoard III from Halle-Kanena differ conspicuously from the so-called classical *Ösenring* metal from elsewhere in their bismuth contents. With an average of 0.02 ± 0.03 %, the concentrations are lower by almost one order of magnitude than those from the classical *Ösenring* copper, which consistently contains bismuth with a mean of 0.15 ± 0.06 % (Junk et al. 2001; Krause 2003; Lauermann/Pernicka 2013) and a median of 0.068 % with an interdecile range of 0.025 and 0.15 %. In consequence, the *Ösenring* copper of the Central German Únětice Culture is not the same as the classical *Ösenring* copper from more southern regions, which indicates different mineralisations from the same deposit or different source regions.

Neither the lead isotope ratios of copper ores in the Harz Mountains nor those from the Erzgebirge provide a convincing match with the objects from Halle-Kanena III (Fig. 10a–b). Therefore, both regions can be excluded as suppliers of the copper, which means that the metal was imported. Unfortunately, the two most promising source regions in Central Europe, namely, the Inn Valley and the Slovakian Ore Mountains, overlap partially in their lead isotope ratios, particularly at lower $^{206}Pb/^{204}Pb$ (≈ 18.4), $^{207}Pb/^{204}Pb$ (≈ 15.66) and $^{208}Pb/^{204}Pb$ (≈ 38.5) ratios (Fig. 10c–d). Only one axe from Halle-Kanena III (MA-071890) is located in this range, but since it represents one pool of copper for mixing, and further artefacts of *Ösenring* copper from other Únětice sites cluster in this isotopic range, it would be important to narrow down the origin of the copper properly. For the

18 Otto/Witter 1952; Junghans et al. 1968; Junghans et al. 1974; Krause 2003; Stöllner et al. 2016; Nørgaard et al. 2021.

19 Martinek/Sydow 2004; Höppner et al. 2005; Schubert/Pernicka 2013; Lauermann/Pernicka 2013; Goldenberg 2015; Pernicka 2017.

Halle-Kanena III artefacts with higher lead isotope ratios (≈18.65; 15.68; 38.65), including the *Ösenrings*, the best match is provided by copper slags of the EBA site at Buchberg (see above), derived from smelting the nearby fahlores (Fig. 10c–d). Incidentally, the ratios of these slags are slightly off the majority of the fahlore samples from the Inn Valley[20]. This is most likely due to the fact that fahlore minerals have exceedingly low concentrations of lead, so that the lead isotope ratios during smelting were probably affected by the host rocks of the ores, which are not necessarily similar. Yet this makes slags the ideal material for comparison with Bronze Age fahlore-type copper. Nevertheless, the question of the origin of the *Ösenring* copper cannot be answered based on lead isotopes ratios alone since there is the aforementioned overlap with ores from Slovakia. Here, the chemical composition may provide another dimension for reasoning. Regarding the chemical composition, i.e., the concentrations of arsenic, antimony, and especially silver and bismuth, the Únětice artefacts of *Ösenring*-type copper are considerably different from that of the fahlores in the Inn Valley and related raw metal products, e.g., from Buchberg (Martinek/Sydow 2004; Schubert/Pernicka 2013; Lutz 2016, 341–342). The contents of bismuth are lower, while the arsenic/antimony ratio with a mean value of 1.2 is higher, indicating a lower proportion of antimony of the original fahlores. Both figures are in contrast with the fahlores in the Inn Valley, which are dominated by antimony-rich tetrahedrite (Martinek/Sydow 2004; Lutz 2016)[21]. Therefore, the chemical compositions appears to be at odds with the lead isotope ratios, so that the Slovakian Ore Mountains must in fact be considered an alternative source regions for the Halle-Kanena III objects and the *Ösenring* copper in general. Because the match in the lead isotope ratios is also not perfect, and chemical data from Slovakia is as yet not sufficient, a final conclusion about copper origin is still pending. Additional data is urgently needed, potentially supplemented by data of other isotope systems, such as copper, silver, and antimony.

The question of copper origin is even more elusive for the nickel-rich fahlore copper. Contra earlier suggestions (Otto/Witter 1952, 32–33; Krause 2003, 160), the production from local ores in the Únětice territory around Halle can meanwhile also largely be excluded due to non-matching lead isotope ratios of relevant copper ores (Fig. 10a–b) (Frotzscher 2012). Instead, it has been speculated that the western, southern, and eastern Alpine regions could be possible source regions for the nickel-rich copper type in general (Krause 1988, 214–218; Krause 2003, 160; Cattin et al. 2015); but, due to a still rudimentary database of nickel-rich fahlores with matching isotopic data, the identification of the potential copper deposits remains difficult. However, it seems possible that the copper does not derive from a single ore deposit, given the large spread in the lead isotope ratios (Cattin et al. 2015). In addition, although being a seemingly homogenous chemical group, nickel-rich artefacts from the Singen cemetery and flanged axes of the so-called Salez type (both ›Singen copper‹; Krause/Pernicka 1998) from the western Alps and the northern foothills, show slightly different trace element patterns (Fig. 14a–b). This in turn can be regarded as an additional indication of the use of more than one source. Nonetheless, the similarity of the copper of the Únětice artefacts with both the copper from Singen and that of the Salez axes is very striking. They not only show similar chemical characteristics, but also overlap in terms of lead isotope compositions (Fig. 14). One may thus speculate with justification on a common source region of the nickel-rich copper in the two cultural spheres, which might in fact be located somewhere in the Alps or in Slovakia (cf. Berger et al. in prep.). In any case, the fahlore occurrences in the Valais (western Alps) show no substantial overlap with the nickel-rich copper objects. Moreover, it is not known whether the ores are associated with nickel minerals. The same applies for ores in Trentino and South Tyrol in the southern Alps, but there is slightly better isotopic overlap with the artefacts (not shown as a diagram here; cf. Berger et al. in prep.). However, available evidence from smelting sites indicates predominating processing of chalcopyrite ores rather than that of the rare occurrences of fahlores (Artioli et al. 2015). The question of the provenance of fahlore copper with nickel is therefore still open, as it is with *Ösenring* copper.

What about the tin?

In various publications, the task of determining the origin of tin in bronze has proven to be challenging (e.g., Berger et al. 2022; Berger et al. 2022a). The sole parameter useful for provenancing tin in bronze is the tin isotope composition; however, it is a less unambiguous proxy when compared, for example, to the lead isotope ratios because of the large data overlap between different tin deposits (Fig. 15). Therefore, the tin isotope composition can only serve to narrow down the origin of tin to a certain extent. Nevertheless, it can provide valuable insights when the values of different artefacts are compared. For instance, when the isotopic systematics of the massive rings from Halle-Kanena III are assessed, different batches and origins of copper are inferred from the disparities in the lead and copper isotope compositions (Tab. 3). Similar conclusions can be drawn from the differing chemical patterns and varying tin contents (4–13 %). In contrast, the very similar tin isotope values ($\delta Sn = 0.093$ to 0.099 ‰·u^{-1}) in three of the rings indicate either the use of the same tin (or tin batch) or tin sourced from the same deposit for the production of the bronze artefacts (Tab. 4). Interestingly, two massive bronze rings of a different type from another hoard (hoard II) from Halle-Kanena (von Brunn 1959, 59), as well as several rings and some axes and one halberd blade from the large and geographically nearby hoards of Dieskau II and III (von Brunn 1959, 55–56), exhibit the same isotopic

20 The majority of the lead isotope data so far available from the Inn Valley fahlores show highly radiogenic signatures with $^{206}Pb/^{204}Pb > 19$.

21 The tetrahedrite fahlores from the Inn Valley usually have much higher antimony than arsenic, leading to an As/Sb ratio of 0.43 (Lutz 2016, 341).

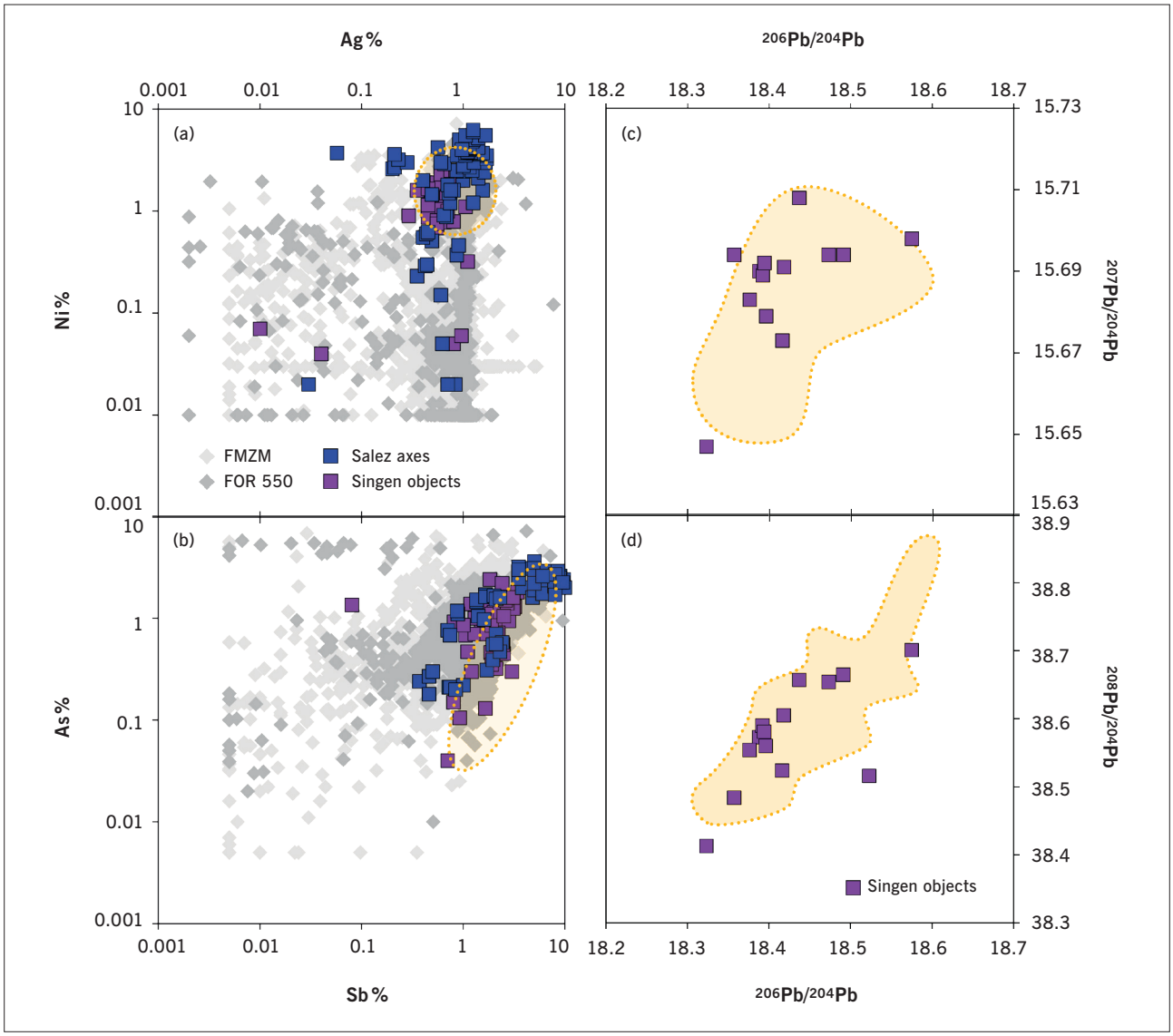

Fig. 14a–d Chemical and lead isotopic composition of EBA nickel-rich metal artefacts from the Singen cemetery (›Singen copper‹), Konstanz district, and the axe hoard from Salez-Sennwald, St. Gallen canton, Switzerland. The dotted and orange-shaded areas in the diagrams mark the composition of the Únětice nickel-rich copper; the grey symbols correspond to data of Únětice artefacts analysed in the FMZM and FOR 550 projects.

Abb. 14a–d *Chemische und Bleiisotopenzusammensetzung von frühbronzezeitlichen nickelreichen Metallartefakten aus dem Gräberfeld von Singen (»Singener Kupfer«), Lkr. Konstanz, und dem Depotfund von Salez-Sennwald, Kanton St. Gallen, Schweiz. Die orange hinterlegten Bereiche im Diagramm markieren die Zusammensetzung des nickelreichen Aunjetitz-Kupfers; die grauen Symbole entsprechen den Aunjetitzer Artefakten, die im Rahmen der Projekte FMZM und FOR 550 untersucht wurden.*

and chemical systematics as those from Halle-Kanena III[22]. Their tin isotope values are almost identical, and nickel-rich fahlores were used as the copper base for every single ring. These results demonstrate that the people in the micro-region around Halle were closely tied in terms of metallurgical traditions, and they accessed both copper and tin from the same mineral deposits for the production of typologically various objects.

Regarding tin specifically, deposits in the Erzgebirge region and southwest Britain (Cornwall) could have supplied the metal, as the tin isotope values correspond to several mineralised regions (Fig. 15). Tin ores from the Vogtland, the Fichtelgebirge, and the Czech Kaiserwald in the Erzgebirge region hardly overlap with the artefact data, making them less likely suppliers for the Únětice bronzes. Similarly, British ores from the Carnmenellis and St. Agnes granites are less probable metal bases, further reducing the list of potential source regions. At the same time, the highly heterogeneous tin concentrations in all rings contradict assumptions that axes also served as ingots (cf. Krause 1988,

22 Data of the objects will be published in Berger et al. in prep. The following nickel-rich objects have similar tin isotope values as the Halle-Kanena III rings. Dieskau II: HK 45:38A = MA-071609 (ring); HK 45:38V = MA-071612 (halberd blade); HK 45:38D = MA-071617 (ring); Dieskau III: HK 37:18h = MA-071654 (ring); HK 37:18f = MA-071660 (ring); HK 37:18g = MA-071661 (ring); HK 37:18l, 228 = MA-071842 (axe); HK 37:18l, 114 = MA-072025 (axe); HK 37:18l, 144 = MA-072055 (axe); Halle-Kanena II: HK 23:188f = MA-071597 (ring); HK 23:188e = MA-071599 (ring).

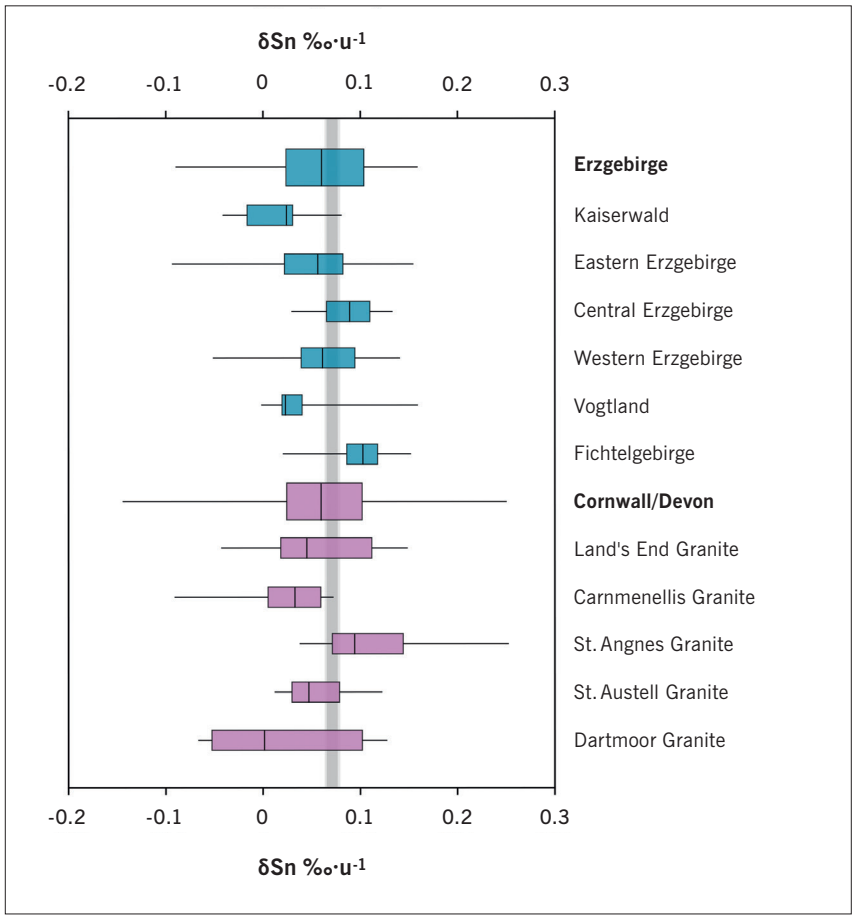

Fig. 15 Tin isotope ranges of tin ores from the Saxon-Bohemian Erzgebirge and Cornwall and Devon, south-west Britain, compared with the tin isotope values of the Únětice artefacts analysed in this study (grey bar). Some areas are statistically more likely than others due to better data overlap with the artefacts. Note that the isotope composition of the objects was corrected by -0.025 ‰·u^{-1} to account for the fractionation during tin ore smelting (cf. Berger et al. 2018; Berger et al. 2022a).

Abb. 15 *Zinisotopenbereiche von Zinnerzen aus dem sächsisch-böhmischen Erzgebirge sowie aus Cornwall und Devon, Südwestengland, im Vergleich zu den Zinnisotopenwerten der Aunjetitzer Artefakte, die im Rahmen dieser Studie analysiert wurden (grauer Balken). Einige Bereiche sind statistisch wahrscheinlicher als andere aufgrund der besseren Datenüberschneidung mit den Artefakten. Man beachte, dass die Isotopenzusammensetzung der Objekte um -0,025 ‰·u^{-1} korrigiert wurde, um der Fraktionierung während des Verhüttens des Zinnerzes gerecht zu werden (vgl. Berger et al. 2018; Berger et al. 2022a).*

219–232; Krause 2003, 198). On the one hand, inconsistent bronze quality resulting from the highly variable tin contents is principally detrimental to their function as ingots. On the other, the careful working of the surfaces of the massive rings and their use-wear traces suggests that they are not in the as-cast state, which is at odds with the character of ingots as defined by G. Billig (2000) (cf. Moucha 2005, 44).

Whereas the bronze of the rings results from alloying copper and tin deliberately, the situation is a different one for items with only minor tin below 0.4 %. This applies to the axes of high-nickel copper and those of Group II derived from copper with variable nickel. There is a common belief that such low concentrations of tin are naturally introduced by the smelted copper ores (Pernicka 1990; Tylecote 1992, 18–19), which therefore seems to be the most plausible explanation for the presence of tin in the analysed artefacts. This gains support on first glance when considering the tin concentrations in fahlores (tetrahedrite) from the Alpine region (Tropper et al. 2019). Mineral samples from the fahlore mineralisations of Schwaz, Röhrerbühel and Bartholomäberg in Austria can in fact contain anywhere from hundreds up to thousands of µg g^{-1}, which would add up to 0.1–0.5 % in the smelted metal. The same has been observed in a few ore samples from the Slovakian Ore Mountains (Schreiner 2007). However, all minerals are associated with low nickel concentrations and are more closely related to the *Ösenring* copper type. Consequently, the inference from this would be that artefacts from *Ösenring* copper may contain tin. However, upon assessing Únětice objects and contemporary artefacts from other regions of *Ösenring* composition, including EBA raw copper[23], it becomes evident that they either contain no tin or deliberate additions exceeding 2 % (Fig. 12a). The same is observed with nickel-poor casting cakes of fahlore copper from the Late Bronze Age, which never contain tin (Möslein/Pernicka 2019). Hence, tin could not have entered the Halle-Kanena III artefacts with variable nickel contents through *Ösenring* copper or naturally through its ore base.

In consequence, this draws attention to the nickel-rich fahlore copper and its ores. Unlike *Ösenring* copper, there is little evidence for raw fahlore copper with high nickel concentrations: neither from the Early nor from the Late Bronze Age. Two notable exceptions are the two EBA raw copper pieces and related ores mentioned above from Buchberg and Kiechlberg in Austria, which have high nickel concentrations, but again contain no tin (Otto/Witter 1952, 204 Nr. 1276; Martinek/Sydow 2004; Lutz 2016, 342). However, since the data is statistically not reliable, and chemical data of relevant nickel-bearing fahlores are largely missing, it is difficult to judge the potential introduction of tin through this ore base. From the limited data available in the litera-

23 Otto/Witter 1952; Schubert/Pernicka 2013; Martinek/Sydow 2004; Möslein/Pernicka 2019, Nr. 636.

ture, one is inclined to exclude fahlores as the source of minor tin, since tin is either not mentioned or present only in very low concentrations (e.g., George et al. 2017). Another possibility could be that tin is enriched along with nickel and cobalt in weathered fahlores, such as those from the Schwaz-Brixlegg district, for which there is currently no indication.

This leaves the possibility of deliberately mixing bronzes from nickel-rich fahlore copper with a high tin content with tin-free of the same copper type to obtain objects with low or medium concentrations of tin. From a metallurgical standpoint, such a practice might seem paradoxical as the better properties of high-tin bronzes are lowered when their tin content is reduced. However, it remains a viable option, especially when metal recycling is taken into account. The continuous distribution of the tin contents across all artefacts of nickel-rich fahlore copper from the Circum-Harz group without a substantial gap may serve as an indicative argument for mixing (Fig. 12a). It is not observed for objects made from *Ösenring* copper, exhibiting a gap between < 0.005 and 2 % of tin (Fig. 12a). Additionally, a slightly negative correlation between tin and arsenic in the nickel-rich artefacts of the Circum-Harz group, as well as in the axes of the Salez type, further corroborates the hypothesis of mixing, since negative elemental trends are hardly to be explained by natural phenomena. And, finally, mixing lines between the tin isotope composition and independent parameters such as the copper isotope values of the nickel-rich material in the hoard of Dieskau III are also in line with this theory (Berger et al. in prep.). Utilising such mixed and low-tin metal would, in turn, entail decreasing tin contents when mixed with tin-free *Ösenring* copper and thus lead to chemical characteristics as observed in the Group II artefacts of the Halle-Kanena III hoard. The presence of low tin concentrations in the fahlore copper with variable nickel contents would then be in line with an anthropogenic reason and not with a natural origin.

Conclusions

This article has presented data of chemical and isotopic analyses of the entire collection of Únětice metal artefacts from the Halle-Kanena III hoard, which includes 61 objects, predominantly flanged axes. Except for one item, all objects consist of fahlore-type copper, though they do not represent a uniform type of metal. The assemblage comprises objects crafted from fahlore copper with high nickel contents and fahlore copper without nickel (*Ösenring* copper). Moreover, there is a fahlore-based variant used exclusively for axes and standing out for highly variable nickel and simultaneously constant silver. Following our combined assessment of chemical and isotopic data, including copper isotope values, we propose that this specific metal in the hoard results from mixing batches of nickel-rich fahlore copper and *Ösenring* copper. The absence of distinct mixing lines across all data combinations, which would be expected if portions of only one batch of nickel-rich copper and one batch of *Ösenring* copper were mixed, leads us to conclude that the artefacts with variable nickel were produced from two or more pools of either copper type over a more or less extended period. This accounts for the observed overall trends without clear mixing lines, marking an important finding with major archaeometallurgical and archaeological implications.

The practice of metal mixing in the Únětice Culture represents currently the earliest instance in the Central European Bronze Age. It is paralleled by observations in the Nordic Late Neolithic II (2100–1700 BC), when finished objects were imported and recast into axes of local types (Nørgaard et al. 2021; see Melheim in this volume). There, it is quite possible that more than one finished object was required to cast one local axe, which naturally would qualify as metal mixing. Nevertheless, despite the added evidence for mixing in the Bronze Age, it is a far cry from the notion that all metal objects were regularly mixed and recycled. If this were the case, neither compositional and isotopic groupings nor mixing lines in data would show up in objects specifically distributed in space and time.

Nevertheless, the mixing of materials, even more so of different metal types, complicates conclusions about the origins of the ore sources used. When the end members, i.e., the raw materials, for mixing are known or can reasonably be assumed, as in this study, the origin of copper can be determined by separately discussing the two raw materials. In the case of the nickel-rich and *Ösenring* fahlore copper from Halle-Kanena III, for example, the Alps and/or Slovakia are presently the most likely source regions for the copper. However, the signatures of the mixing products do not reliably point to these source regions, making accurate provenancing challenging, especially when the end members are missing and only a limited number of analysed objects is available. This underscores the importance of analysing a larger set of objects. Analyses of only a few or even a single object may lead to erroneous interpretations in the absence of comparative data sets (cf. also Berger et al. 2024).

Another question that arises from the findings in this study concerns whether we are dealing with the mixing of raw copper or the recycling of materials. Even though often confused, the meaning of the aspects is not the same: Recycling implies any reuse of material by humans without the necessity of mixing or remelting metal (Kershaw/Merkel 2022). Mixing, for its part, invariably entails blending two or more components or materials, whether through human action or natural processes. Determining the specific metallurgical practice behind the axes with variable nickel from the Halle-Kanena III hoard is not a straightforward task because, in theory, both processes could lead to the same analytical results. To clarify this ambiguity, it is therefore essential to include archaeological information from the find complex and the wider archaeological context of the Únětice Culture and Central Europe.

A critical aspect of this question is the state and condition of the axes, which offer insights into their use and manufacture. Many objects are damaged, have elongated lobes at the edges, or show scratches, bevels, and signs of edge grinding (Fig. 6; see also Bunnefeld et al. in this volume). These marks attest to the extensive use and reworking of the objects during their lifetime, while no significant differences could be observed for the axes made from the different types of copper. The objects are thus tools or weapons rather than mere

Fig. 16a–b Salez type axe from the homonymous hoard at Sennwald, St. Gallen canton, Switzerland (a), and one of the Saxon type from the Halle-Kanena III hoard (b).

Abb. 16a–b *Beil vom Typ Salez aus dem gleichnamigen Hort von Sennwald, Kanton St. Gallen, Schweiz (a), und Beil vom sächsischen Typ aus Depot III von Halle-Kanena (b).*

axe ingots (Billig 2000; Kienlin 2008, 295–301). However, within each copper category, a few axes appear to be intermediate products or blanks (cf. Fig. 7; Tab. 1)[24], as it is also true for objects identified, e.g., in the hoards from Oldisleben, Kyffhäuser district, and Nieder-Neundorf, Görlitz district (von Brunn 1959, Taf. 68 and 70). The flanges of these semi-finished items are partially or entirely missing, and their shapes and cutting edges are underdeveloped. They were most likely cast in stone or clay moulds (Billig 1957; Billig 2000) and – according to recent metallographic examinations of two axes from the Halle-Kanena III hoard (see Michael et al. in this volume) – forged after casting to shape the final form. The presence of both blanks and finished axes within the same hoard and across all copper types emphasises the interpretation that the axes in question were locally produced by Únětice smiths and not imported as finished objects.

The latter perspective was discussed previously by R. Krause (1988; 2003) in the context of the circulation of nickel-rich fahlore copper in Central Europe, specifically of the Singen type. On the basis of his observations and chemical analyses, R. Krause proposed the concept of ›axe ingots‹ as trade goods, which he saw in the Salez type axes from Switzerland and south-western Germany, on the one hand, and the Central German axes of the Saxon type, on the other. Both types are in fact typologically similar (Fig. 16), but, unlike the Salez type axes, the Únětice axes of the Saxon type were not restricted to nickel-rich fahlore copper, but were also made of *Ösenring* copper, copper with variable nickel, and low-impurity copper, as exemplified by the artefacts from Halle-Kanena III. This diversity makes it even more unlikely that these axes ever arrived in the Únětice territory as finished objects, and it is equally unlikely that the Salez axes were locally remelted to produce similar axes anew[25].

All these points are strong indications that the production of the axes and the mixing of copper took place in Central Germany. The absence of discernible (typological) differences among the axes from the various copper types suggests that pieces consisting of variable nickel copper are not mere products of recycling but represent mixtures of raw copper from the other two copper sorts. How exactly and in which form this copper arrived in the Únětice territory (*Ösenring* copper partly as *Ösenrings*), and how it was handled and processed, is another story. Comparison with metalwork from other Únětice hoards shows that metal mixing must have been a widespread metallurgical practice in the whole region and beyond already in the first quarter of the 2nd millennium BC (Berger et al. in prep.). This finding provides both challenges and new avenues for future research.

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24 HK 34:305l, 15, 25, 26, 27 (?), 28, 29, 30, 35 and 36 (cf. Tab. 1).

25 For a more detailed discussion about the interpretation of axes as ingots see Kienlin 2008, 293–312.

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2 D. Berger, data: J. Lutz, from Krause 2003 and FOR 550 (unpublished)
3 von Brunn 1959, Taf. 43
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6–7 J. A. Soldevilla
8 D. Berger, data: J. Lutz, from Krause 2003 and FOR 550 (unpublished)
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16 J. A. Soldevilla, S. Gridling, P. Grutsch

Tab. 1 D. Berger, J.-H. Bunnefeld
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Werkzeuge, Waffen, Würdezeichen. Beile und Äxte der Aunjetitzer Kultur in Mitteldeutschland

Jan-Heinrich Bunnefeld, Christian-Heinrich Wunderlich, Harald Meller und Roberto Risch

Summary

Tools, Weapons, and Symbols of Dignity: Axes of the Únětice Culture in Central Germany

In this contribution, the Early Bronze Age axes of Central Germany will be evaluated according to their typology and chronology and, above all, their production method, function, and significance. Our evaluation is based on experimental tests, metallographic investigations, morphotechnical analyses, and a detailed re-examination of the flanged axes and ribbed »double axes« of the Dieskau type from the hoards of the Dieskau microregion.

The large number and variety of the Central German Únětice axes demonstrate their great importance. The biggest group, the Saxonian flanged axes, mainly stems from hoards that contain up to 300 specimens. Their basic shape is fairly uniform, with numerous variations, and they were centrally produced from cast blanks that were intensively forged. Several smiths were demonstrably involved in the manufacture of each individual axe, probably in a workshop, of the hoard from Dieskau III. According to their occasionally extensive use-wear, the flanged axes served as tools and weapons, whereas an application as ingots and standards of value can pretty much be ruled out. The axes that do show signs of wear had been used in a similar way and probably together before being deposited in various hoards. The Únětice rulers most likely awarded the axeheads to their men-at-arms.

The ribbed »double axes« are solely known from hoards. They had no practical function but are to be interpreted as status symbols or insignia that were not put into the graves. Other, sometimes unique, axes may also be interpreted as symbols of status or dignity. Among them are tin-bronze axes (which once shone like gold and were found in a few graves such as the princely graves), the early socketed axe from Kütten-Dobritz, the crest-butted axe from Naumburg, and the Nordic Fårdrup axe from Löbschütz, as well as two imported »Anglo-Irish« flanged axes and their imitations. These partially foreign shapes were only deposited outside of graves.

The gold axe from Dieskau was an exceptional and almost singular status symbol in the Early Bronze Age of Central Europe. It might originally have been discovered in the monumental burial mound called Bornhöck and certainly belonged to the very top of Únětice society. The princely graves and other outstanding burials often contained Neolithic stone axes that had probably served to legitimise rule. Although the finds stem from the entire Central German distribution area of the Únětice Culture, the particular wealth of the Dieskau microregion and the thus expressed power of the local rulers are obvious in particular against the background of the concentration in number and variety of axes there.

Zusammenfassung

Die frühbronzezeitlichen Beile und Äxte in Mitteldeutschland werden in Hinblick auf ihre Typologie und Chronologie, vor allem aber ihre Herstellungstechnik, Funktion und Bedeutung ausgewertet. Die Grundlage bilden eine detaillierte Neuaufnahme der Randleistenbeile und gerippten »Doppeläxte« vom Typ Dieskau aus den Hortfunden der Mikroregion um Dieskau, experimentelle Versuche, metallografische Untersuchungen und morphotechnische Auswertungen.

Die hohe Anzahl und Vielfalt an Beilen und Äxten in der mitteldeutschen Aunjetitzer Kultur demonstriert ihre große Bedeutung. Die größte Gruppe bilden die Sächsischen Randleistenbeile, die vor allem in Hortfunden mit bis zu 300 Exemplaren auftreten. Sie verfügen über eine relativ einheitliche Grundform mit zahlreichen Variationsmöglichkeiten und wurden zentralisiert aus intensiv überschmiedeten Rohlingen hergestellt. Beim Hortfund von Dieskau III lässt sich nachweisen, dass die Beile jeweils von mehreren Handwerkern wohl in einer Werkstatt geschmiedet wurden. Angesichts ihrer zum Teil umfangreichen Gebrauchsspuren wurden die Randleistenbeile offenbar als Werkzeuge und Waffen verwendet, während eine Funktion als Barren und genormte Wertmaßstäbe praktisch auszuschließen ist. Sofern sie Gebrauchsspuren tragen, wurden die Beile der einzelnen Horte vor der Niederlegung auf ähnliche Weise und wohl gemeinsam genutzt. Wahrscheinlich wurden die Beilklingen von den Aunjetitzer Fürsten an die Männer verliehen, die ihnen als Bewaffnete dienten.

Die gerippten »Doppeläxte« treten ausschließlich in Hortfunden auf. Sie hatten keine praktische Funktion, sondern sind als Statussymbole oder Insignien zu interpretieren, die aber nicht in die Gräber gelangten. Daneben gibt es andere, zum Teil einzigartige Beile und Äxte, die ebenfalls als Statussymbole oder Würdezeichen gedeutet werden können. Dazu zählen zinnbronzene, einst goldfarben glänzende Beile, die sich in wenigen Gräbern – darunter den Fürstengräbern – finden, das frühe Tüllenbeil von Kütten-Dobritz, die Nackenkammaxt von Naumburg und die nordische Axt vom Typ Fårdrup von Löbschütz, aber ebenso zwei importierte »anglo-irische« Randleistenbeile und ihre Imitationen. Diese zum Teil fremden Formen wurden nur außerhalb von Gräbern deponiert.

Das goldene Beil von Dieskau, das womöglich ursprünglich im monumentalen Grabhügel Bornhöck entdeckt wurde und sicherlich der absoluten Spitze der Aunjetitzer Gesellschaft zuzuordnen ist, stellt ein herausragendes und in der Frühbronzezeit Mitteleuropas fast einzigartiges Statussymbol dar. Weiterhin wurden in den Fürstengräbern und anderen herausgehobenen Gräbern regelhaft neolithische Steinäxte gefunden, die wahrscheinlich zur Legitimation von Herrschaft gedient haben. Auch wenn die Funde über das gesamte mitteldeutsche Verbreitungsgebiet der Aunjetitzer Kultur

Keywords Early Bronze Age, axe, forging, metal craft organisation

streuen, sind der besondere Reichtum der Mikroregion Dieskau und die darin zum Ausdruck kommende Macht der dortigen Herrscher vor dem Hintergrund der dort konzentrierten Anzahl und Vielfalt von Beilen und Äxten unverkennbar.

Schlagwörter Frühbronzezeit, Beil, Axt, Schmieden, Organisation des Metallhandwerks

1. Einleitung

Während die frühesten Metallbeile in Mitteldeutschland bereits aus dem späten 5. Jt. v. Chr. stammen und Importe aus dem südöstlichen Europa darstellen, sind aus der Schnurkeramik- und Glockenbecherkultur in der Region keine kupfernen Beile bekannt (Maraszek u. a. 2011). Stattdessen spielten in der Schnurkeramikkultur polierte und zum Teil facettierte Steinäxte eine bedeutsame Rolle als Waffen und Statussymbole (u. a. Schwarz 2015). Erst mit der Frühbronzezeit und der Aunjetitzer Kultur (2200–1550 v. Chr.) treten wieder Metallbeile und auch -äxte auf. Sie gewannen offenbar schnell große Bedeutung als Werkzeuge, Waffen und Würdezeichen.

Neben den bekannten Fürstengräbern, die u. a. Beile enthalten, ist die Circumharzer Gruppe der Aunjetitzer Kultur durch umfangreiche Hortfunde gekennzeichnet (von Brunn 1959; Meller 2013, 516 f. Tab. 2). Vor allem aus der Mikroregion um Dieskau, Saalekreis, unweit von Halle (Saale), liegen zahlreiche Deponierungen vor, die bis zu knapp 300 Beile umfassen (Abb. 1)[1]. Bereits früh wurde bemerkt, dass es sich hierbei um eine Reichtumsregion handelt, die in der Frühbronzezeit Mitteleuropas ihresgleichen sucht (Montelius 1900, 77 f.; Jahn 1950; vgl. Maraszek 2012). Nicht nur die hohe Dichte von Fundstellen und die außergewöhnlich umfangreichen Hortfunde bestätigen diese Einschätzung (vgl. Filipp/Freudenreich 2016), sondern auch die Ausgra-

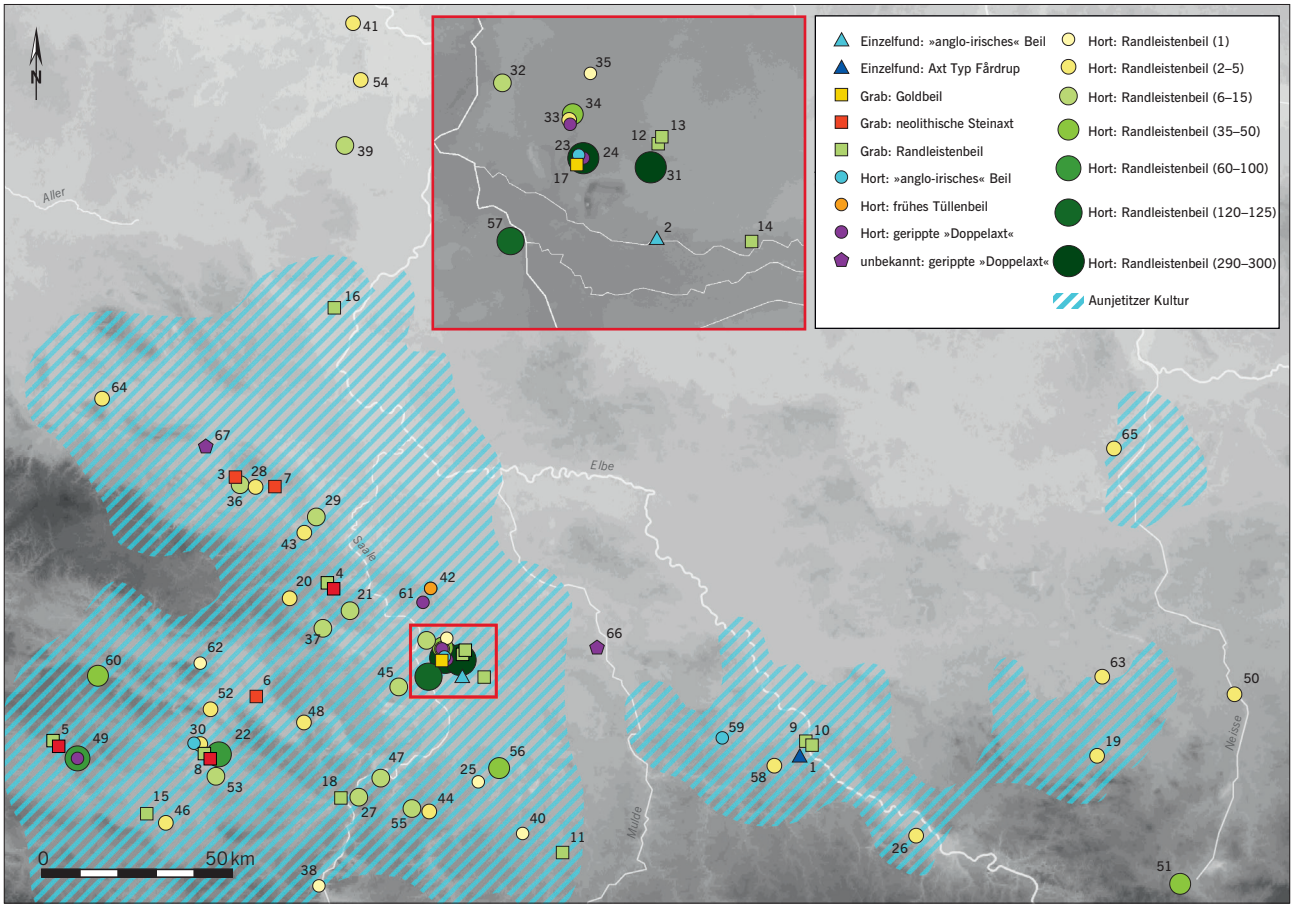


Abb. 1 Verbreitung der verschiedenen Beile und Äxte in Mitteldeutschland. Deutlich sticht die Konzentration von großen Beilhorten um Dieskau hervor (vgl. Liste 1).

Fig. 1 *Distribution map of various axe types in Central Germany. The concentration of large axe hoards around Dieskau clearly stands out (see List 1).*

1 Eine Übersicht findet sich in Meller 2019b, 151 Abb. 6.

bung des einstigen Großgrabhügels Bornhöck und die Auffindung eines Goldfundes, der wahrscheinlich in Verbindung mit dem Bornhöck gebracht werden kann[2].

Obwohl die Deponierungen bei Dieskau international bekannt sind und immer wieder angeführt werden (z. B. Bradley 2017; Fontijn 2019), fehlt bisher eine detaillierte Vorlage der Funde und Analysedaten[3]. Die Horte enthalten vor allem sogenannte Sächsische Randleistenbeile und wenige gerippte »Doppeläxte« vom Typ Dieskau. Will man alle frühbronzezeitlichen Beile und Äxte in Mitteldeutschland berücksichtigen, kommen einige andere Randleistenbeile, »anglo-irische« Beile mit westeuropäischen Wurzeln, die neolithischen Steinäxte aus herausragenden Bestattungen oder Einzelstücke wie die Nackenkammaxt von Naumburg, Burgenlandkreis, und das Goldbeil von Dieskau hinzu.

Auf der Grundlage einer Neuaufnahme der Randleistenbeile und gerippten »Doppeläxte« aus den Hortfunden der Mikroregion um Dieskau, experimenteller Erfahrungen und statistischer Auswertungen werden in der vorliegenden Studie vor allem die Herstellungstechnik, Funktion und Bedeutung dieser Beile und Äxte diskutiert. Vergleichend werden auch die übrigen mitteldeutschen Beile und Äxte betrachtet, wobei Metallanalysen die Unterscheidung zwischen importierten und lokal nachgeahmten »anglo-irischen« Beilen unterstützen.

Die morphotechnische Untersuchung aller Sächsischen Randleistenbeile aus dem Hortfund Dieskau III hatte zum Ziel, die Arbeitsweisen und den Ablauf der Schmiedeprozesse zu verstehen. Anhand der Regelmäßigkeit der Schmiedeprozesse sollte geprüft werden, ob dieser Satz von metrisch sehr ähnlichen Artefakten in einer oder in mehreren Werkstätten hergestellt worden ist. Diese Frage ist, zusammen mit der Analyse der Gebrauchsspuren, entscheidend, um die Zusammensetzung der Horte mit sehr ähnlichen Beilen zu verstehen. Insbesondere sollte diese Kombination von Beobachtungen klären, ob die Beile – vor allem in großen Horten – einheitlich hergestellt wurden und ob sie in gebrauchtem oder ungebrauchtem Zustand niedergelegt worden sind.

Die Ergebnisse werfen ein weiteres Schlaglicht auf die komplexen politischen, sozialen und ökonomischen Strukturen der mitteldeutschen Frühbronzezeit, die offenbar zu einem gewissen Grad zentralisiert waren.

2. Methodik

Zur ausführlichen Neubewertung der Beile und Äxte wurden die Fundstücke aus den Horten der Mikroregion um Dieskau[4] detailliert neu untersucht. Neben dem Messen und Wiegen erfolgte eine makro- und mikroskopische Untersuchung auf Herstellungs- und Gebrauchsspuren. Natürlich hängt die Beurteilung der Schmiede-, Schleif- und Gebrauchsspuren stark vom Erhaltungszustand ab. Korrosion, aber auch alte Restaurierungsmaßnahmen schränken die Aussagemöglichkeiten in einigen Fällen deutlich ein. Zum besseren Verständnis der Spuren wurden von Herbert R. Bauer, Halle (Saale), einem ausgebildeten Kupferschmied, experimentelle Arbeiten durchgeführt. Seine Expertise wurde in die Auswertung einbezogen[5].

Parallel wurden metallografische Untersuchungen zur genauen Charakterisierung der Herstellungstechnik an zehn Beilen vorgenommen, wobei Längs- und Querschnitte untersucht wurden. Ein Teil der Ergebnisse wird in diesem Band veröffentlicht (s. Beitrag Michael u. a.).

Die morphotechnische Analyse der Randleistenbeile wurde anhand von fünf Merkmalen (A–E) durchgeführt, die auf unterschiedliche Arbeitsweisen beim Schmieden zurückgehen, jedoch keine Auswirkung auf die Funktion der Beile hatten (Abb. 2; Tab. 1). Während die Merkmale A–D das Ergebnis vom Schmieden in der Herstellungsphase sind, kam es zur Verformung der Beilklinge (Merkmal E) vor allem beim Nachschmieden und Schleifen der Beile in ihrer Gebrauchszeit. Die Kombination von metrischen mit morphotechnischen Variablen wurde untersucht, um Produktionsprozesse zu identifizieren und die Standardisierung der Produkte zu bestimmen. Dabei können Kombinationen von unterschiedlich gestalteten bzw. geschmiedeten morphotechnischen Merkmalen bei metrisch standardisierten Beilen als Herstellungsweisen verstanden werden.

Die metrische Variabilität der Beile wurde anhand von fünf Parametern bestimmt (Tab. 2). Die vier Maße entsprechen den üblichen Dimensionen, die an Beilen gemessen werden. Ihr Gewicht ist wichtig, um die Metallmasse und Effizienz ihrer Verarbeitung (BK/Gewicht) zu bestimmen.

Die Gewichte der Beile wurden unter Berücksichtigung der Wahrnehmbarkeitsschwelle analog zur Arbeit von M. Kuijpers und C. Popa ausgewertet (Kuijpers/Popa 2021).

Die Ergebnisse der Untersuchungen werden im Folgenden unter Berücksichtigung der vielfältigen Forschungen in den letzten Jahrzehnten diskutiert. Diese Studie enthält keine umfassende Auswertung der bislang unveröffentlichten Metallanalysen, die nur an einzelnen Stellen – wie bei der Differenzierung zwischen importierten und lokal imitierten »anglo-irischen« Beilen – explizit berücksichtigt werden (s. Beitrag Berger u. a. in diesem Band; Berger u. a. in Vorb.)[6]. Ebenso wird ein ausführlicher Katalog der Beile auch unter Berücksichtigung der Gebrauchsspuren an anderer Stelle publiziert (Meller in Vorb.).

3. Sächsische Randleistenbeile

3.1. Grundlagen und Forschungsgeschichte

3.1.1 Typologie

Der größte Teil der Beile kann den Sächsischen Randleistenbeilen zugeordnet werden. A. Lissauer führte die Bezeich-

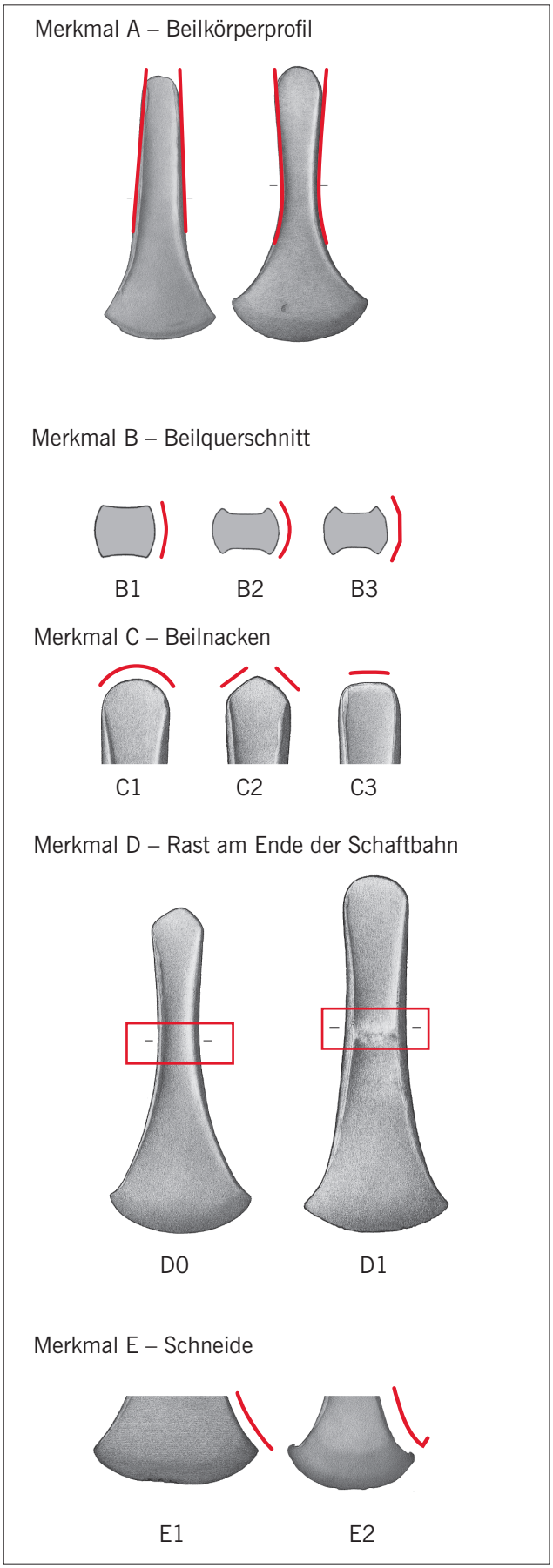
2 Meller/Schunke 2016; Meller 2019a; Meller 2020; Risch u. a. 2021.

3 Eine umfangreiche Vorlage und Auswertung befinden sich in Vorbereitung (Meller in Vorb.).

4 Es handelt sich um die beilführenden Horte Dieskau II–III, Gröbers-Bennewitz I, Halle-Kanena II–III und Schkopau.

5 Wir danken Herbert R. Bauer herzlich für seine Arbeit sowie zahlreiche hilfreiche Hinweise und Ideen.

6 Neue Metallanalysen wurden hauptsächlich im Rahmen der DFG-finanzierten Forschergruppe FOR 550 im CEZA Mannheim durchgeführt.

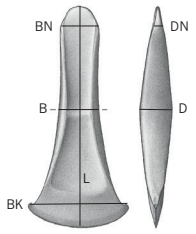


Merkmal A – Beilkörperprofil	
1	Gerade Beilkörperprofile
2	Nach innen geschwungene (konkave) Beilkörperprofile
Merkmal B – Beilquerschnitt	
1	Rechteckiger Beilquerschnitt und Fehlen von Randleisten
2	Gerundete Randleisten
3	Facettierte Randleisten
Merkmal C – Beilnacken	
1	Runde Nackenform
2	Spitze Nackenform
3	Flache Nackenform
Merkmal D – Rast am Ende der Schaftbahn	
0	Nicht vorhanden
1	Vorhanden
Merkmal E – Schneide	
1	Einfache Schneide
2	Schneide mit nach hinten gebogenen Enden

Tab. 1 Technische Merkmale von Randleistenbeilen.

Tab. 1 *Technical characteristics of flanged axes.*

L	Beillänge
BK	Breite der Beilklinge
B	Breite des Beilkörpers
D	Maximale Beildicke
BN	Maximale Breite des Nackens
DN	Beilkörperdicke im Nackenbereich
G	Gewicht



Tab. 2 Metrische Variablen der Randleistenbeile.

Tab. 2 *Metric variables of flanged axes.*

nung ein und definierte als Kriterien eingezogene Schmalseiten, einen gerundeten, dreieckigen oder geraden Nacken und eine flach bogenförmige Schneide (Lissauer 1904, 546) (Abb. 3). Nach kleinen Abweichungen in der Form untergliederte K. Kibbert die Beile in die Varianten Halle, Salez, Carsdorf, Veltheim und Bennewitz[7], die aufsteigend nach Länge angeordnet sind (Kibbert 1980, 157 f.). A. Szpunar bezeichnete die Sächsischen Randleistenbeile in Polen als Typ Wrocław-Szczytniki, wobei auch von ihm größere Exemplare als Typ Bennewitz abgesondert wurden (Szpunar 1987, 20–39). F. Laux unterteilte die niedersächsischen Stücke auch nach der Klingenform, die allerdings sicher durch Gebrauch verändert ist, in zahlreiche Typen, die er nach ihren Fund-

Abb. 2 Übersicht der erfassten Merkmale von Randleistenbeilen und ihre Varianten.

Fig. 2 *Overview of the recorded characteristics of flanged axes and their variants.*

7 Der Typ Bennewitz wurde bereits von H. Otto benannt (Otto 1957/58, 209 Taf. 4).

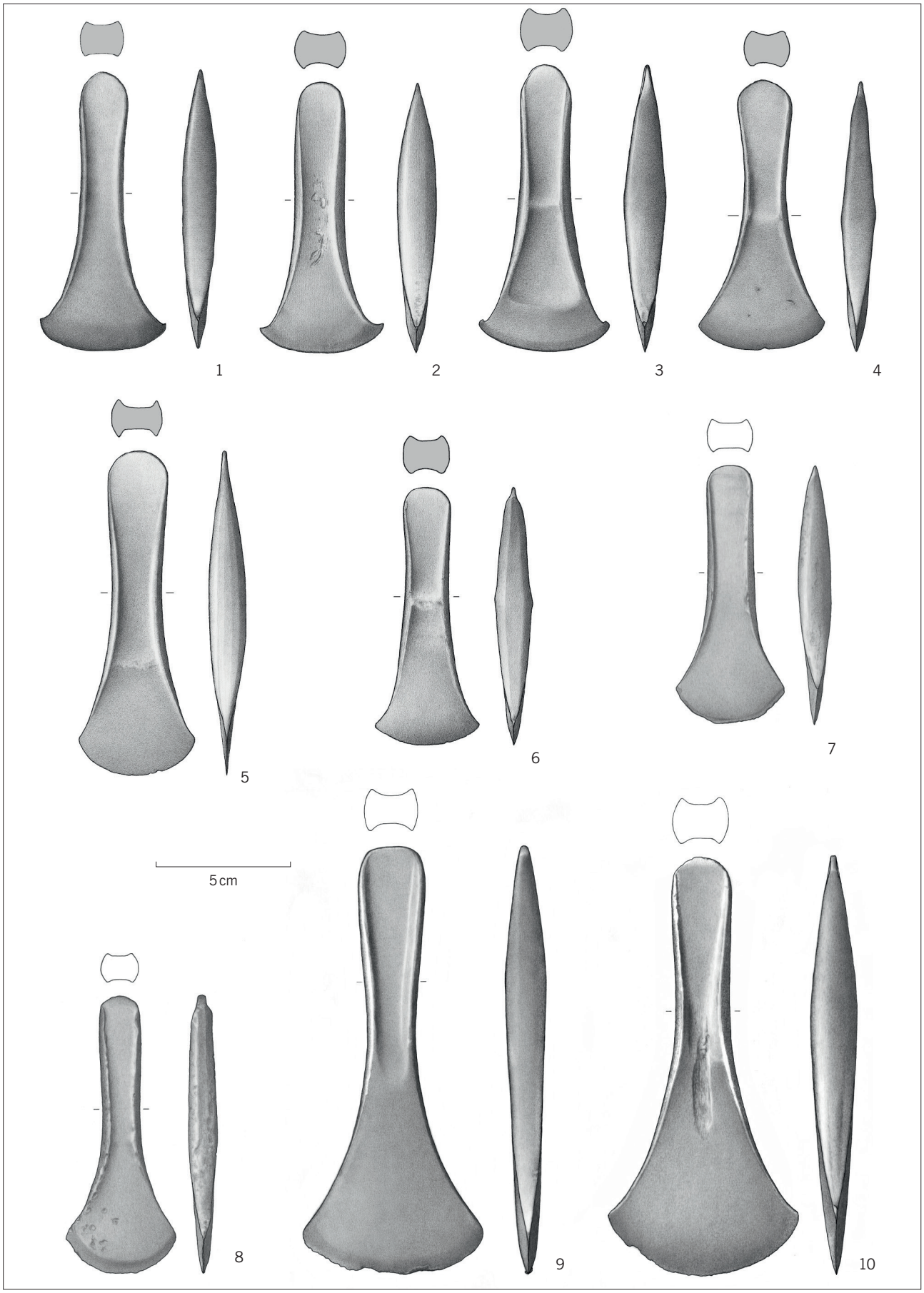


Abb. 3 Auswahl der Varietäten von Sächsischen Randleistenbeilen aus den Horten Dieskau III (1–6), Halle-Kanena III (7–8) und Gröbers-Bennewitz I (9–10), alle Saalekreis.

Fig. 3 *Selection of the varieties of Saxonian flanged axes from the hoards Dieskau III (1–6), Halle-Kanena III (7–8), and Gröbers-Bennewitz I (9–10), all Saalekreis district.*

orten benennt (Laux 2000, 29–37). Zur großen Familie der Sächsischen Randleistenbeile ist auch der nordalpine Typ Salez zu zählen (Abels 1972, 4–10; Mayer 1977, 76). Letztlich bildet eine bereits von Lissauer erkannte Grundform die Basis, von der scheinbar zahllose Variationen existieren. Die Beile aus den umfangreichen Horten Dieskau III und Halle-Kanena III wurden von R. Schwarz nach ihren Umrissen, aber auch anhand der Nackenform nachvollziehbar und detailliert untergliedert, während die Klingen angesichts ihrer Veränderbarkeit durch Nachschärfen nur in Ausnahmefällen berücksichtigt wurden (Schwarz 2019).

Angesichts der neuen Erkenntnisse zur Herstellung durch den Guss von fast identischen Rohlingen wohl aufgrund identischer Model und umfassendes anschließendes Ausschmieden von Körper und Klinge, bei dem die Form offenbar durchaus verändert wird (s. u.), erscheint eine hochauflösende differenzierte typologische Auswertung der Beile jedoch nicht zielführend. Es ist zu erkennen, dass den Beilen in unterschiedlichen Horten bestimmte, teils leicht abweichende Normen bzw. Model zugrunde lagen. Zahlreiche Unterschiede zwischen Dieskau III und Halle-Kanena III scheinen jedoch eher durch die Anwesenheit von Halbfabrikaten im letztgenannten Komplex hervorgerufen zu werden.

3.1.2 Fundkontexte

Die meisten Sächsischen Randleistenbeile finden sich in den Hortfunden, die eingangs bereits erwähnt wurden. Die besonders umfangreichen Funde mit bis zu 297 Stücken konzentrieren sich in der Mikroregion um Dieskau, aber auch im Thüringer Becken sind mit Dermsdorf, Lkr. Sömmerda, und Neunheilingen, Unstrut-Hainich-Kreis, größere Hortfunde bekannt (s. Abb. 1). Einzelfunde liegen natürlich ebenfalls vor, spielen aber keine entscheidende Rolle, wenngleich sie nicht genau quantifizierbar sind.

Aus sehr wenigen, überwiegend reichen Gräbern in Mitteldeutschland sind Sächsische Randleistenbeile bekannt (u. a. Zich 1996, 215–220; Meller 2019b, 150 Anm. 9) (Abb. 4). Aus dem Fürstengrab von Leubingen, Lkr. Sömmerda, stammen zwei Fundstücke aus Zinnbronze, wovon eines einen einzigartigen konkaven Nacken hat (Klopfleisch 1878; Höfer 1906; Meller 2019c). Das Fürstengrab von Helmsdorf, Lkr. Mansfeld-Südharz, enthält ein besonders langes und schmales, in Längsrichtung mittig mit einem Tannenzweigmuster verziertes Sächsisches Randleistenbeil aus Zinnbronze, das einigen »langgestielten Beilen« aus Dermsdorf entspricht[8]. Diese zinnbronzenen Beile aus Gräbern hatten nicht nur mögliche funktionale Vorzüge, sondern glänzten ursprünglich goldfarben und dienten sicherlich auch als Statussymbole (Meller 2019b).

In Naundorf, Lkr. Meißen (Grab 2: Billig 1958, 41 f.; Zich 1996, 533 Nr. K161), und Walschleben, Lkr. Sömmerda (Zich 1996, 217; 504 Nr. F293), lag jeweils ein kupfernes Sächsisches Randleistenbeil im Grab[9]. Möglicherweise ist das Beil von Großheringen, Lkr. Weimarer Land, ebenfalls ein Grabfund (Zich 1996, 495 Nr. F152).

3.1.3 Datierung

Die Sächsischen Randleistenbeile gehören der klassischen und nachklassischen Aunjetitzer Kultur an (AK 3–4 nach Schwarz 2021, d. h. Bz A1b–A2b nach Ruckdeschel 1978), sind aber schwierig genauer zu datieren (Zich 1996, 215–217; vgl. Schwarz 2021). Die chronologischen Ansichten zur Feindatierung der Sächsischen Randleistenbeile von Billig, der Beile mit Rast oder anderem »Halt« in der Bahnmitte als jünger ansieht, und von Brunn, der alle Hortfunde einem einzigen Horizont am Ende der Aunjetitzer Kultur zuschreibt, sind überholt (Billig 2000 [1956] 7; von Brunn 1959, 16–36).

Jüngere Überlegungen gehen von einer chronologischen Aussagekraft der genutzten Materialsorten aus (Rassmann 2005; Lorenz 2010; Schwarz 2019). K. Rassmann ordnet die Materialsorten mitteldeutscher Randleistenbeile den Metallverarbeitungshorizonten II und III nach Krause zu, datiert diese aber zum Teil etwas älter (Rassmann 2005; vgl. Krause 2003). L. Lorenz übernimmt die Einteilung in die Materialsorten Dederstedt, Bresinchen, Bennewitz, Kläden und Trebbichau und vergleicht sie mit der Typologie der Objekte, vor allem der Beile, in den Hortfunden (Lorenz 2010). Kienlin folgend gliedert sie die Beile in die Typen Salez, Sächsische Randleistenbeile, Neyruz und Langquaid (Lorenz 2010; vgl. Kienlin 2008). Damit ist diese Einteilung natürlich zu grob, um zu einer differenzierten Datierung der Beile im Circumharzer Raum zu gelangen. Beide Autoren stützen sich auf ^{14}C-Datierungen aus dem Hort Melz II, Lkr. Mecklenburgische Seenplatte, und dem Fürstengrab (Hügel I, Grab A) von Łęki Małe, Woj. Wielkopolskie (Polen), die teils sehr hohe Standardabweichungen und im Vergleich zur gut abgesicherten archäologischen Chronologie zu alte Daten geliefert haben[10].

Schwarz differenziert die Beile aus Dieskau III und Halle-Kanena III chronologisch anhand der sich zum Teil unterscheidenden Umrissformen und Kupfersorten und stellt sie den dendrochronologisch datierten Beilen aus den Fürstengräbern von Leubingen und Helmsdorf gegenüber. Dabei kommt er zu dem Schluss, dass die Dieskauer Beile in Phase AK 3a (bei Schwarz 2019 als Phase Bz A2a1 bezeichnet) und die Stücke aus Halle-Kanena III in Phase AK 3b (Bz A2a2) gehören (Schwarz 2019)[11]. Allerdings bestehen die Beilformen V4, H1, H4, Y1 und Y2, die ausschließlich oder hauptsächlich in Halle-Kanena III auftreten, in ihrer Mehrzahl aus Halbfabrikaten (s. u.; vgl. Schwarz 2019, 116 Tab. 1; 131 f.). Daher kann das Ergebnis letztlich nicht bestätigt werden, wenngleich das Auftreten bestimmter Beilformen ausschließlich in Dieskau III und die Nutzung unterschied-

8 Größler 1907; Meller 2019c; Schwarz 2019; vgl. Küßner/Wechler 2019, 450.

9 Für die Metallanalysen siehe die erweiterte SAM-Datenbank, FMZM0525 und FMZM0306 bzw. FMZM2215 (Krause 2003, CD-Rom).

10 Schwenzer 2002; Meller 2024, 675 f.; Czebreszuk u. a. 2024, 26; 30 f. Abb. 15–16; 36–38; vgl. Schwarz 2021.

11 Ein kleiner Unterschied in der Terminologie und absoluten Datierung zwischen den beiden Publikationen Schwarz 2019, 130 und Schwarz 2021, 34; 222 hinsichtlich der Grenze zwischen AK 3a (Bz A1b) und 3b (Bz A1b/A2a) ergibt sich aus der ausführlicheren, auf der Keramik beruhenden Studie zur Chronologie der mitteldeutschen Aunjetitzer Kultur (Schwarz 2021).

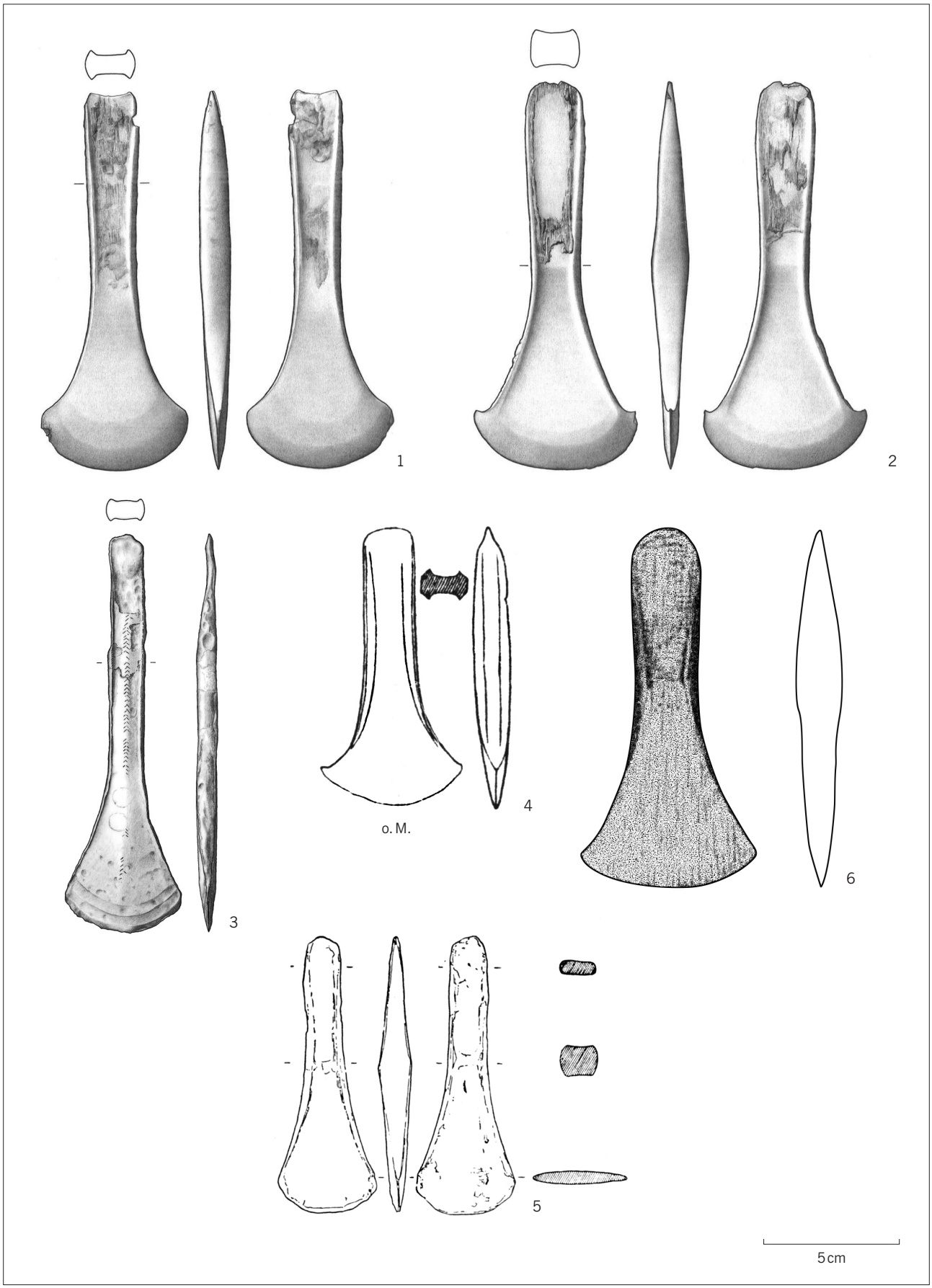


Abb. 4 Nur in sehr wenigen Gräbern treten Sächsische Randleistenbeile auf: 1–2 Leubingen, Lkr. Sömmerda; 3 Helmsdorf, Lkr. Mansfeld-Südharz; 4 Naundorf, Lkr. Meißen (Grab 2); 5 Walschleben, Lkr. Sömmerda; 6 Großheringen, Lkr. Weimarer Land.

Fig. 4 *Saxonian flanged axes only occur in very few graves: 1–2 Leubingen, Sömmerda district; 3 Helmsdorf, Mansfeld-Südharz district; 4 Naundorf, Meißen district (grave 2); 5 Walschleben, Sömmerda district; 6 Großheringen, Weimarer Land district.*

licher Kupfersorten für eine feinchronologische Differenzierung sprechen könnten.

Größere Beile, die den Hort Gröbers-Bennewitz I bilden, werden jünger datiert (AK 4/Bz A2b) (Kibbert 1980, 163 f.; Szpunar 1987, 36–39; Schwarz 2019, 128). Dazu passt, dass diese Beile aus einer anderen Kupfersorte bestehen und vielfach einen Zinngehalt von einigen Prozent aufweisen, während die älteren kaum Zinn enthalten[12].

Der Hort von Dermsdorf enthält insgesamt 98 Beile, die typochronologisch ältere (kleine Sächsische Randleistenbeile, sog. Typ Salez) ebenso wie jüngere Formen (große, zinnhaltige Sächsische Randleistenbeile, »langgestielte Beile«, Typ Neyruz) repräsentieren, letztere oft aus zinnhaltigem Metall. Vermutlich traten diese Formen etwas zeitversetzt auf und wurden zeitweise gleichzeitig produziert. Eine weitere Erklärung könnte sein, dass die Beile aus Dermsdorf über längere Zeit gesammelt wurden. Auch wenn er in seiner Heterogenität sehr ungewöhnlich ist, warnt dieser Befund vor dem Versuch, die Beile chronologisch zu fein zu gliedern und in eine klare Abfolge bringen zu wollen (Küßner/Wechler 2019, 449–457).

3.1.4 Herstellungstechnik

Die Herstellung der Sächsischen Randleistenbeile ist schon des Öfteren thematisiert worden. Sie bestehen aus Kupfer oder Bronze mit niedrigem Zinngehalt, wobei letzteres vor allem für die jüngeren Stücke gilt (Lockhoff u. a. 2019; Schwarz 2019; s. Beitrag Berger u. a. in diesem Band). In der älteren Forschung herrschte die Ansicht vor, dass die Beile nach dem Guss in allen Teilen ausgeschmiedet wurden (von Brunn 1950, 240 f.; Billig 1957, 299; Billig 1961, 102). Hingegen kam T. Kienlin in seiner metallografischen Studie zu den nordalpinen Randleistenbeilen zu dem Schluss, dass die Sächsischen Randleistenbeile in zweischaligen Gießformen mit bereits angelegten Randleisten gegossen und außer im Klingenbereich nicht wesentlich überschmiedet wurden (Kienlin 2008, 173; 185; Kienlin 2010, 828). Seine Proben wurden jedoch fast ausschließlich aus den Schneiden entnommen. Die lediglich zwei untersuchten Proben aus dem Beilkörper stammen von Stücken aus Zinnbronze, deren Herstellungsweise sich durchaus von den üblichen kupfernen Stücken unterschieden haben kann (vgl. Kienlin 2008, 174).

Wie zu zeigen ist, spielte das Ausschmieden nach dem Guss des Rohlings eine entscheidende Rolle. Zudem sind sicherlich nicht alle Beile auf die gleiche Weise hergestellt worden (vgl. Kuijpers 2018, 183 f.).

3.1.5 Funktion

Zur Funktion und Bedeutung der Sächsischen Randleistenbeile wurde viel geschrieben. Hier werden die wesentlichen Diskussionsbeiträge mit besonderem Augenmerk auf Mitteldeutschland kurz zusammengefasst. Aufgrund der intensiven Nachschärfung nahm G. Billig einen primären Gebrauch als Arbeitsgeräte und nur sekundär, insbesondere für Beile aus Gräbern, Funktionen als Waffen und Würdezeichen an (Billig 1957, 310). Ähnlich sah T. Kienlin die Rolle der Beile im nordalpinen Raum (Kienlin 2006; Kienlin 2008, 293–312).

K.-H. Otto interpretierte die Beile dagegen in erster Linie als Waffen, aber auch als »Beilgeld« (Otto 1955, 19 f.; 44; vgl. Gerloff 1940). H. Meller und R. Schwarz wiesen ihnen ebenfalls eine primäre Funktion als Waffen zu und interpretieren die Hortfunde als Überreste bewaffneter Truppen im Dienst der Aunjetitzer Fürsten[13].

R. Krause deutete die aus homogenem Kupfer bestehenden Salezer Beile im nordalpinen Raum hauptsächlich als Barren, da sie vom Material den Funden aus dem Gräberfeld Singen am Hohentwiel, Lkr. Konstanz, entsprechen (Krause 1988, 219–232). M. Lenerz-de Wilde untersuchte die Hortfunde Dieskau III und Bresinchen, Lkr. Spree-Neiße, sowie weitere Sächsische Randleistenbeile auf ihr Gewicht. Während rund 20 % der Beile aus Dieskau III 120–130 g und rund 17 % der Beile in Bresinchen 160–170 g wiegen, gibt es in beiden Fundkomplexen zahlreiche Beile, die etwas leichter bzw. schwerer sind. Bei den übrigen berücksichtigten Beilen ist kein angestrebtes Mittelgewicht erkennbar. Aus diesem Grund und aufgrund der Gebrauchsspurenanalysen von Billig nahm Lenerz-de Wilde an, dass die mitteldeutschen Beile als Schatzgut gehortet wurden, aber nicht als genormte Wertmaßstäbe oder Tauschmittel dienten (Lenerz-de Wilde 1995, 302–304). M. Kuijpers und C. Popa kamen anhand ihrer Stichprobe jedoch zu dem Ergebnis, dass einige Beile, ebenso wie Ösenringe und Spangenbarren, aufgrund ihrer auch formübergreifenden Gewichtsähnlichkeit als genormte Tauschmittel angesehen werden können (Kuijpers/Popa 2021).

In eine ganz andere Richtung zielte C. Berends, der eine mögliche Funktion ungeschäfteter Randleistenbeile als Mittel zur Klangerzeugung anführte (Berends 2010, 21–26).

3.2 Morphotechnische Analyse

Alle vier Maße und das Gewicht der Beile korrelieren signifikant miteinander. Die fünf verwendeten metrischen Variablen (s. Tab. 2) verteilen sich innerhalb der einzelnen Horte symmetrisch (Normalverteilung) und ihre Variationsbreiten ähneln sich – abgesehen von wenigen Ausreißern[14] – stark (vgl. Kibbert 1980, 158; Schwarz 2019, 117) (Tab. 3). Demnach bestehen auch die größeren Horte aus metrisch relativ einheitlichen Artefakten. Unterschiedliche Werkzeug- oder Waffenarten sind anhand der metrischen Variabilität nicht zu erkennen (Abb. 5). Auch zwischen verschiedenen Horten, wie Dieskau III und Halle-Kanena III, sind die Beile oft metrisch kaum zu differenzieren, was auf sehr ähnliche Guss- und Schmiedeabläufe hindeutet. Besonders eng ist üblicherweise das Verhältnis zwischen dem

12 Rassmann 2005; Lorenz 2010; Lockhoff u. a. 2019, 136 f.; Meller 2019b, 149 f. Abb. 5a.

13 Siehe z. B. Meller 2013, 519; Schwarz 2014, 726; 729; Meller 2015; Meller 2017; Schwarz 2019.

14 In Dieskau III fällt z. B. ein Beil von 15,2 cm Länge auf (HK 37:18l, 273). Bemerkenswert ist zudem ein mit ca. 22 cm Länge besonders großes Sächsisches Randleistenbeil aus dem Hortfund von Neunheilingen, Unstrut-Hainich-Kreis, das unter anderem zusammen mit 60 Beilen normaler Größe gefunden wurde (Billig 1957, 312; von Brunn 1959, 63 f.).

Hort		Beil-länge (L) (cm)	Breite der Beilklinge (BK) (cm)	Breite des Beil-körpers (B) (cm)	Maximale Beildicke (D) (cm)	Maximale Breite des Nackens (BN) (cm)	Beilkörper-dicke im Na-ckenbereich (DN) (cm)	Gewicht (G) (g)
Dieskau III	Durchschnitt	10,13	4,56	1,69	1,34	1,84	0,41	137,40
	Standardabweichung	0,88	0,41	0,21	0,13	0,17	0,08	28,53
	Median	10,10	4,55	1,70	1,35	1,83	0,40	131,50
Halle-Kanena III	Durchschnitt	10,34	4,73	1,80	1,22	1,73	0,43	127,83
	Standardabweichung	0,75	0,51	0,18	0,20	0,18	0,09	33,25
	Median	10,30	4,70	1,85	1,20	1,74	0,43	119,00
Schkopau	Durchschnitt	11,19	4,51	1,97	1,27	1,92	0,48	176,76
	Standardabweichung	1,55	0,72	0,29	0,17	0,26	0,10	59,75
	Median	11,16	4,50	1,92	1,25	2,01	0,50	183,20
Gröbers-Bennewitz I	Durchschnitt	15,82	6,54	2,07	1,51	2,37	0,58	330,20
	Standardabweichung	0,73	0,36	0,18	0,14	0,17	0,12	31,77
	Median	15,85	6,50	2,06	1,50	2,36	0,58	331,00

Tab. 3 Maße und Gewichte der Sächsischen Randleistenbeile in den Hortfunden.

Tab. 3 *Dimensions and weights of Saxonian flanged axes from hoards.*

Gewicht der Beile und allen vier Maßen (Abb. 6). So sind z. B. die Beile aus dem Hortfund Gröbers-Bennewitz I zwar deutlich schwerer als jene aus den Horten Dieskau III und Halle-Kanena III, folgen aber derselben Symmetrie und Effizienz im Verhältnis zwischen verwendetem Rohmaterial und Länge der Schneidefläche. Mit anderen Worten: Mit Zunahme des Gewichtes wurde auch die Länge, Breite und Dicke der Beile tendenziell proportional erhöht, was wiederum ein Indiz einer sehr standardisierten Herstellung ist. Diese Symmetrie scheint auch durch Nachschmieden und -schleifen beibehalten worden zu sein, denn es ist metrisch nicht erkennbar, dass ein leichter, durch Gebrauch verursachter Material- bzw. Gewichtsverlust mit einer asymmetrischen oder nicht proportionalen Verschmälerung der Klingen einherging.

Um einen Einblick in die Produktionsabläufe zu bekommen, wurde der Hortfund Dieskau III morphotechnisch und morphometrisch untersucht. Wie zu erwarten, korrelieren alle gemessenen Dimensionen signifikant miteinander und vor allem mit dem Gewicht der Beile (Tab. 4a). Folglich wurden im Hort Beile von leicht unterschiedlicher Größe und Gewicht (s. Abb. 5–6), aber von sehr ähnlicher Symmetrie deponiert. Im Gegensatz dazu korrelieren die morphotechnischen Merkmale der Beile nicht (Tab. 4b), was auf unter-

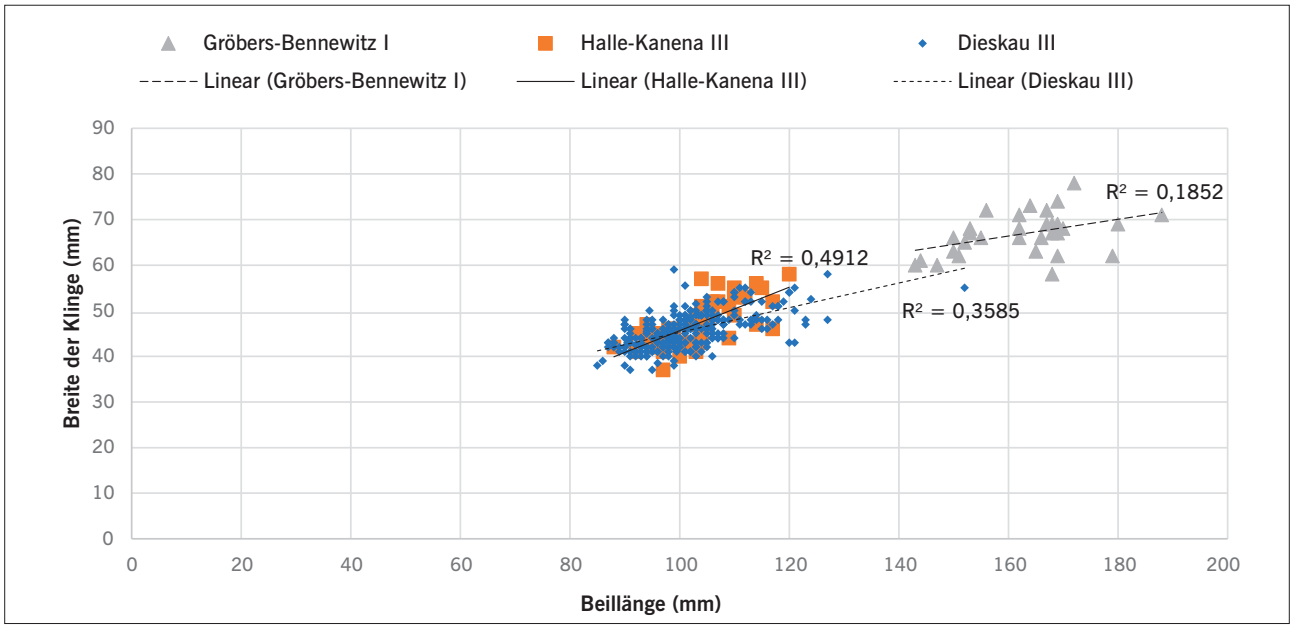


Abb. 5 Verhältnis zwischen Länge (L) und Klingenbreite (BK) der Beile aus drei bedeutenden Horten Mitteldeutschlands.

Fig. 5 *Ratio between the length (L) and width (BK) of axeheads from three important Central German hoards.*

a

Metrische Variablen	L	BK	B	D	Gewicht
L	1				
BK	0,539	1			
B	0,373	0,16	1		
D	0,297	0,345	0,275	1	
Gewicht	0,801	0,583	0,644	0,61	1

b

Morphotechnische Merkmale	A	B	C	D	E
A Beilprofil	1				
B Beilschnitt	-0,147	1			
C Beilnacken	-0,136	-0,016	1		
D Rast	0,129	0,11	-0,082	1	
E Beilklinge	0,055	0,114	0,019	0,112	1

Tab. 4a–b Korrelationswerte zwischen metrischen Variablen (a; s. Tab. 2) und morphotechnischen Merkmalen (b) aus dem Hort Dieskau III.

Tab. 4a–b *Correlation values between metric variables (a; see Tab. 2) and morphotechnical characteristics (b) from the Dieskau III hoard.*

schiedliche Herstellungs-, insbesondere Schmiedeprozesse hindeutet.

Bei einer Herstellung in unterschiedlichen Werkstätten wäre zu erwarten, dass vor allem die Schmalseiten, der Nacken und die Schaftbahn in bestimmter und sich wiederholender Weise bearbeitet wurden. In diesem Fall würden sich Werkstätten und Handwerker durch bestimmte Herstellungsweisen, die anhand der Kombination technischer Merkmale ohne Einfluss auf die Funktion der Beile erkennbar sind, unterscheiden. Dies ist jedoch eindeutig nicht der Fall, da keine Merkmalskombination signifikant erscheint (s. Tab. 4b).

Das Fehlen technischer Regelmäßigkeiten wird auch durch die niedrigen Korrelationswerte der Beilklinge unterstrichen. Da davon ausgegangen werden kann, dass die Form der Klinge im Gegensatz zu den anderen Merkmalen vor allem auf unterschiedliches Nachschmieden zurückzuführen ist, sind ihre Korrelationswerte als rein zufallsbedingte Ergebnisse (H0) zu verstehen. Da alle anderen Korrelationswerte – ob mit positiven oder negativen Zeichen ist hierbei unwichtig – ähnlich ausfallen, sind auch diese Kombinationen von morphotechnischen Merkmalen im Hort Dieskau III als Zufallsresultate zu verstehen (s. Tab. 4b).

Diese Beliebigkeit wird auch durch das fast vollkommene Fehlen regelmäßiger Kombinationen zwischen technischen Merkmalen und metrischen Variablen unterstrichen. So variiert z. B. die Länge und Breite der Beile nicht in Bezug auf den Beilquerschnitt, also der geschmiedeten Form der Schmalseiten (Abb. 7). Bei anderen technischen Merkmalen überlappen sich die metrischen Werte in ähnlicher Weise. Nur die geringere Körperbreite von Beilen mit leicht einschwingenden, konkaven Schmalseiten im Gegensatz zu den breiteren rechteckigen Beilprofilen ist signifikant, aber auch ein zu erwartendes Ergebnis (Abb. 8).

Angesichts dieser morphotechnischen Vielfalt stellt sich die Frage nach den Herstellungsweisen bei den Beilen aus Dieskau III. Mit anderen Worten: Wie viele Beile wurden in den unterschiedlichen Kombinationen von morphotechnischen Merkmalen gestaltet (Tab. 5)? Hierbei dürfen nur

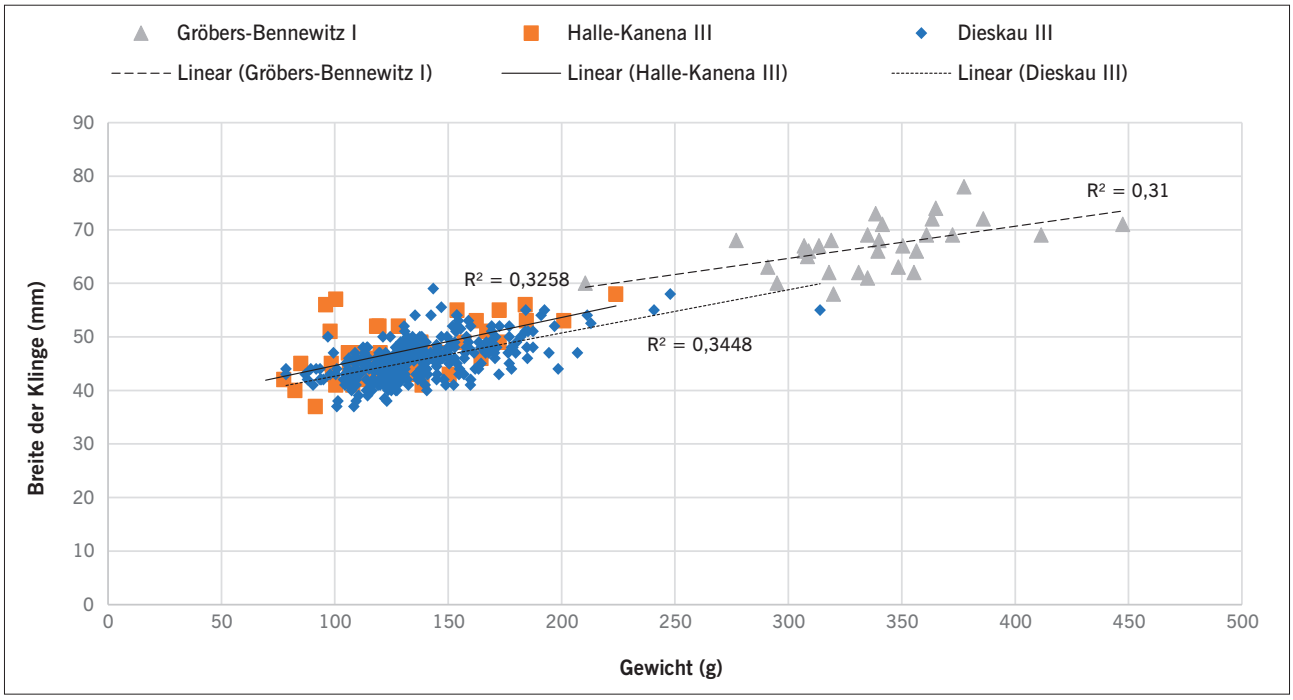


Abb. 6 Verhältnis zwischen Gewicht und Klingenbreite (BK) der Beile aus drei bedeutenden Horten Mitteldeutschlands.

Fig. 6 *Ratio between the weight and width (BK) of axeheads from three important Central German hoards.*

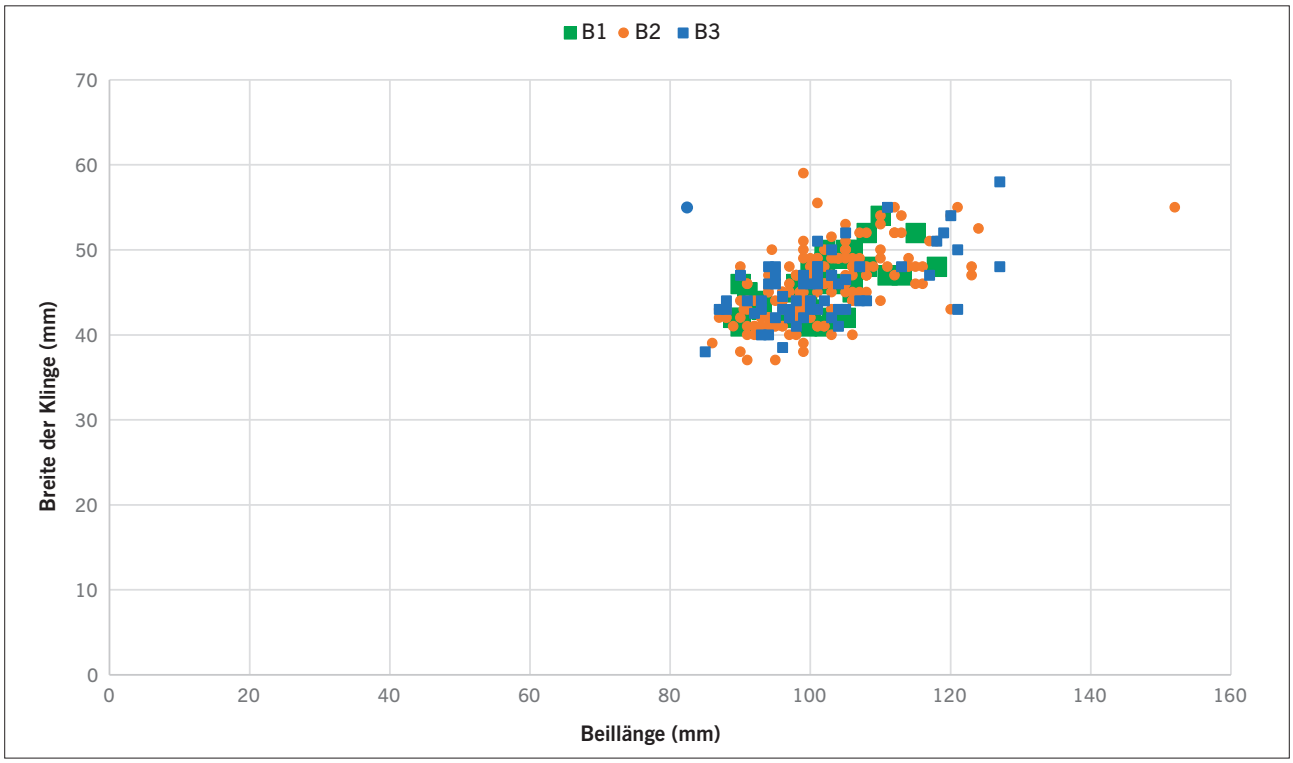


Abb. 7 Verhältnis zwischen Beillänge (L) und Klingenbreite (BK) der Beile aus Dieskau III mit unterschiedlich geformten Schmalseiten (Varianten 1–3 bei Merkmal B; s. Abb. 2).

Fig. 7 *Ratio between the length (L) and width (BK) of the axeheads from Dieskau III with differently shaped narrow sides (characteristic B, variants 1–3; see Fig. 2).*

die technischen Merkmale A–D berücksichtigt werden, da anscheinend allein sie durch den Herstellungsprozess bedingt sind, während die Form der Klinge (Merkmal E) auch ein Ergebnis des Nachschmiedens bzw. -schleifens ist. Insgesamt ergeben sich aus den beobachteten technischen Optionen bei diesen vier Merkmalen maximal 36 Kombinationsmöglichkeiten (s. Abb. 2). Im Dieskauer Hort sind 33 von diesen Herstellungsweisen vertreten, was wiederum die vielfältigen Formen des Schmiedens widerspiegelt (Tab. 6)[15].

Die Erwartung, dass die morphotechnischen Merkmale in ähnlicher Wiese ausgeführt wurden und somit zu Regelmäßigkeiten in der Herstellungsweise führten, erfüllt sich im Falle der Beile aus Dieskau III nicht. Anhand der Häufigkeit der beobachteten Kombinationen von Merkmalen sind eindeutig zwei Herstellungsweisen zu erkennen, die zusammen 84 Beile erzeugten (29 % der vollständig untersuchten Beile). Sie zeigen ein nach innen geschwungenes Beilkörperprofil, rund geschmiedete Leisten und runde Nackenformen. Ihr einziger Unterschied liegt darin, ob eine Rast in der Bahn vorhanden ist (s. Tab. 6; Codes 2-2-1-0 und 2-2-1-1). Zwei ähnliche Herstellungsweisen sind an 44 Beilen zu erkennen (14 %), die jedoch spitze anstelle von runden Nacken aufweisen (s. Tab. 6; Codes 2-2-2-0 und 2-2-2-1). Auch hier besteht der Unterschied lediglich in der Rast, die bei rund der Hälfte der Beile vorhanden ist (Tab. 5). Eine weitere, relativ häufige Produktion schmiedete Beile mit geradem, statt konkavem Profil. Dabei wurde meistens auf die Rast verzichtet, während flache Nacken deutlich beliebter waren (s. Tab. 6; Codes 1-2-1-0 und 1-2-3-0). Zusammen handelt es sich aber nur um 27 Beile (9 %). Alle anderen Herstellungsweisen sind

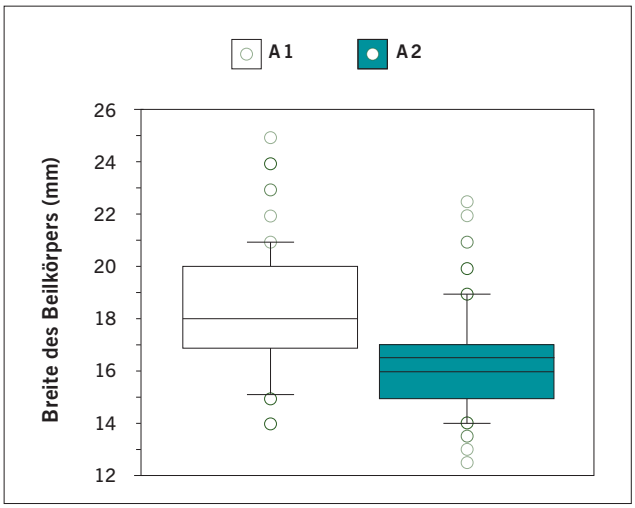


Abb. 8 Körperbreite von geraden im Vergleich zu konkaven Beilkörperprofilen (Optionen 1–2 bei Merkmal A; s. Abb. 2).

Fig. 8 *Comparison of the width of straight and concave axehead profiles (characteristic A, options 1–2; see Fig. 2).*

15 Die einzigen technischen Kombinationen der Merkmale A–D, die nicht vorkommen, sind 1-1-1-1, 1-1-2-1 und 1-1-3-0.

Merkmal und Variante	Beilprofil		Beilquerschnitt		Beilnacken		Rast		Beilklinge	
	N	%	N	%	N	%	N	%	N	%
0							165	56,7 %		
1	77	26 %	38	13 %	161	56 %	126	43,3 %	144	49,8 %
2	215	74 %	192	66 %	83	29 %			145	50,2 %
3			62	21 %	46	16 %				
Total	292	100 %	292	100 %	290	100 %	291	100 %	289	100 %

Tab. 5 Häufigkeit der unterschiedlichen morphotechnischen Merkmale der Beile aus dem Hort Dieskau III. Nicht alle Varianten können an allen Beilen identifiziert werden (dunkle Felder: nicht zutreffend).

Tab. 5 *Frequency of the various morphotechnical characteristics of the axes from the Dieskau III hoard. Not all variants can be identified for all axes (dark cells: not applicable).*

Herstellungsweise	Beilprofil	Beilquerschnitt	Beilnacken	Rast	Code	Beobachtete Beile (N)	Erwartete Beile (N)
1	1	1	1	0	1-1-1-0	3	3,1
2	1	1	1	1	1-1-1-1	0	2,4
3	1	1	2	0	1-1-2-0	2	1,6
4	1	1	2	1	1-1-2-1	0	1,2
5	1	1	3	0	1-1-3-0	0	0,9
6	1	1	3	1	1-1-3-1	1	0,6
7	1	2	1	0	1-2-1-0	15	15,9
8	1	2	1	1	1-2-1-1	7	12,1
9	1	2	2	0	1-2-2-0	9	8,2
10	1	2	2	1	1-2-2-1	3	6,2
11	1	2	3	0	1-2-3-0	12	4,5
12	1	2	3	1	1-2-3-1	2	3,4
13	1	3	1	0	1-3-1-0	5	5,1
14	1	3	1	1	1-3-1-1	8	3,9
15	1	3	2	0	1-3-2-0	2	2,6
16	1	3	2	1	1-3-2-1	2	2
17	1	3	3	0	1-3-3-0	4	1,4
18	1	3	3	1	1-3-3-1	2	1,1
19	2	1	1	0	2-1-1-0	11	8,8
20	2	1	1	1	2-1-1-1	5	6,7
21	2	1	2	0	2-1-2-0	7	4,5
22	2	1	2	1	2-1-2-1	4	3,4
23	2	1	3	0	2-1-3-0	2	2,5
24	2	1	3	1	2-1-3-1	3	1,9
25	2	2	1	0	2-2-1-0	40	44,5
26	2	2	1	1	2-2-1-1	44	33,9
27	2	2	2	0	2-2-2-0	22	22,9
28	2	2	2	1	2-2-2-1	20	17,5
29	2	2	3	0	2-2-3-0	12	12,7
30	2	2	3	1	2-2-3-1	4	9,7
31	2	3	1	0	2-3-1-0	13	14,3
32	2	3	1	1	2-3-1-1	9	10,9
33	2	3	2	0	2-3-2-0	3	7,4
34	2	3	2	1	2-3-2-1	10	5,6
35	2	3	3	0	2-3-3-0	2	4,1
36	2	3	3	1	2-3-3-1	2	3,1

Tab. 6 Kombinationsmöglichkeiten morphotechnischer Merkmale (Herstellungsweisen) und ihre Häufigkeit unter den Beilen des Hortes Dieskau III. Es werden die beobachtete und die aufgrund der Merkmalshäufigkeit (s. Tab. 5) zu erwartende Häufigkeit angegeben.

Tab. 6 *Possible combinations of morphotechnical characteristics (*Herstellungsweise*, production method) and their frequency among the axes of the Dieskau III hoard. Observed as well as expected frequencies are provided. The latter are calculated according the frequencies of each charateristic (see Tab. 5).*

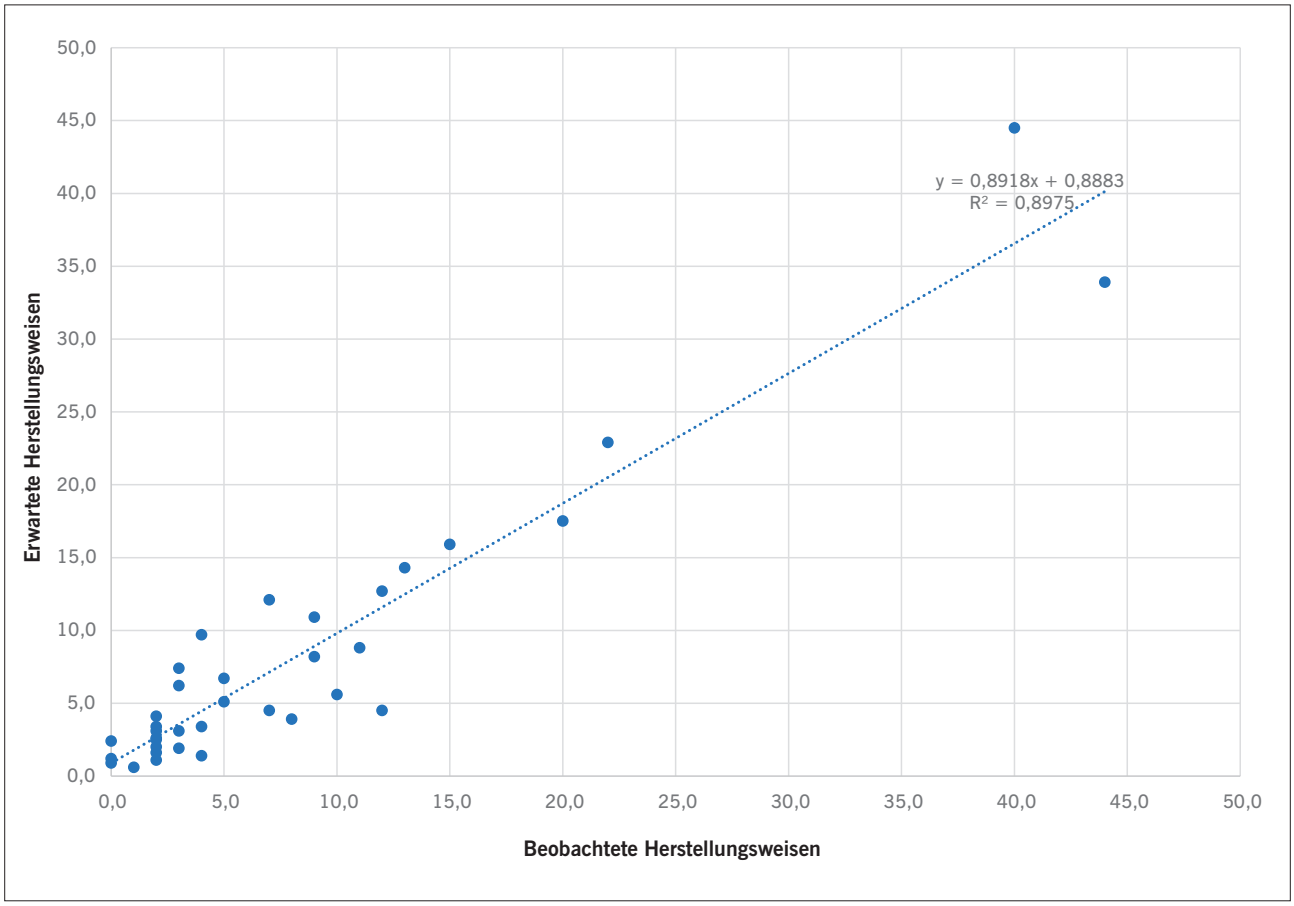


Abb. 9 Beziehung zwischen den beobachteten und den aufgrund der Merkmalshäufigkeit (Tab. 5) zu erwartenden Herstellungsweisen der Beile aus dem Hort Dieskau III.

Fig. 9 *Relation between the observed production methods of the Dieskau III axes and the expected production methods based on the frequency of the characteristics (Table 5).*

noch seltener vertreten. Alleine acht Herstellungsweisen sind nur bei jeweils zwei Beilen nachgewiesen. Eine interessante Beobachtung ist zudem die sehr hohe Korrelation zwischen dem realen und dem erwarteten Vorkommen der Herstellungsweisen, die sich aus der Häufigkeit der einzelnen Merkmale ergibt (Abb. 9; s. Tab. 5). Demnach sind die Merkmalskombinationen höchst variabel, aber nicht gleich verteilt. Vielmehr scheinen regelmäßige Abläufe und Präferenzen beim Schmieden existiert zu haben. Insgesamt ergibt sich somit, dass sehr unterschiedliche Schmiedeprozesse ausgeführt wurden (33 von 36 möglichen), von denen manche jedoch weit beliebter als andere waren. Innerhalb dieser Präferenzen wurden die Schmiedemöglichkeiten jedes Merkmals beliebig miteinander kombiniert, wie aus dem Zusammenfallen von realem und erwartetem Häufigkeitswert hervorgeht.

Zwei mögliche wirtschaftliche Szenarien könnten solch ein Muster erklären. Im ersten Fall würden die Beile aus dem Hort Dieskau III aus einer Vielzahl von kleinen Werkstätten stammen, in denen einzelne Schmiede unterschiedlichen Herstellungsweisen folgten. Gegen diese Option spricht das Fehlen jeglicher metrischer Unterschiede zwischen den Herstellungsweisen (z. B. Abb. 7). Es wäre zu erwarten, dass sich in Werkstätten mit unterschiedlichen Schmiedeprozessen auch Differenzen in den Größen der Beile ergeben.

In einem zweiten Szenario würden alle Beile aus einer oder wenigen Schmieden stammen, in denen mehrere Handwerker tätig waren und sich in den einzelnen Arbeitsschritten abwechselten. Bei einer solchen Organisationsform sind ebenfalls feine Unterschiede in den Schmiedeweisen zu erwarten. Ein Gießen aller Beile in derselben Werkstatt würde hierbei erklären, warum keine morphometrischen Muster, sondern nur Normalverteilungen von Messwerten zu beobachten sind. Angesichts der komplexen und sich wiederholenden Schmiedevorgänge, die bei der Beilherstellung notwendig waren (s. Beitrag Michael u. a. in diesem Band), bietet sich eine solche Arbeitsteilung in den Werkstätten geradezu an, vor allem wenn eine größere Anzahl an Geräten oder Waffen hergestellt werden sollte. Das wiederholte Erhitzen und die begrenzten Schläge, die nach jedem Glühen der Halbfabrikate möglich waren, führte notwendigerweise zu Unterbrechungen in den Arbeitsabläufen, wenn wir von isolierten Handwerkern ausgehen. In einer Werkstatt konnten jedoch mehrere Schmiede an Beilen in unterschiedlichen Fertigungsstadien arbeiten und sie wiederholt erhitzen lassen. In einem solchen Umfeld entwickelten sich erwartungsgemäß Vorlieben für bestimmte Schmiedeformen, die jedoch individuelle Unterschiede bei der Arbeit nicht verhinderten, solange sie keinen Einfluss auf die Qualität des Produktes hatten.

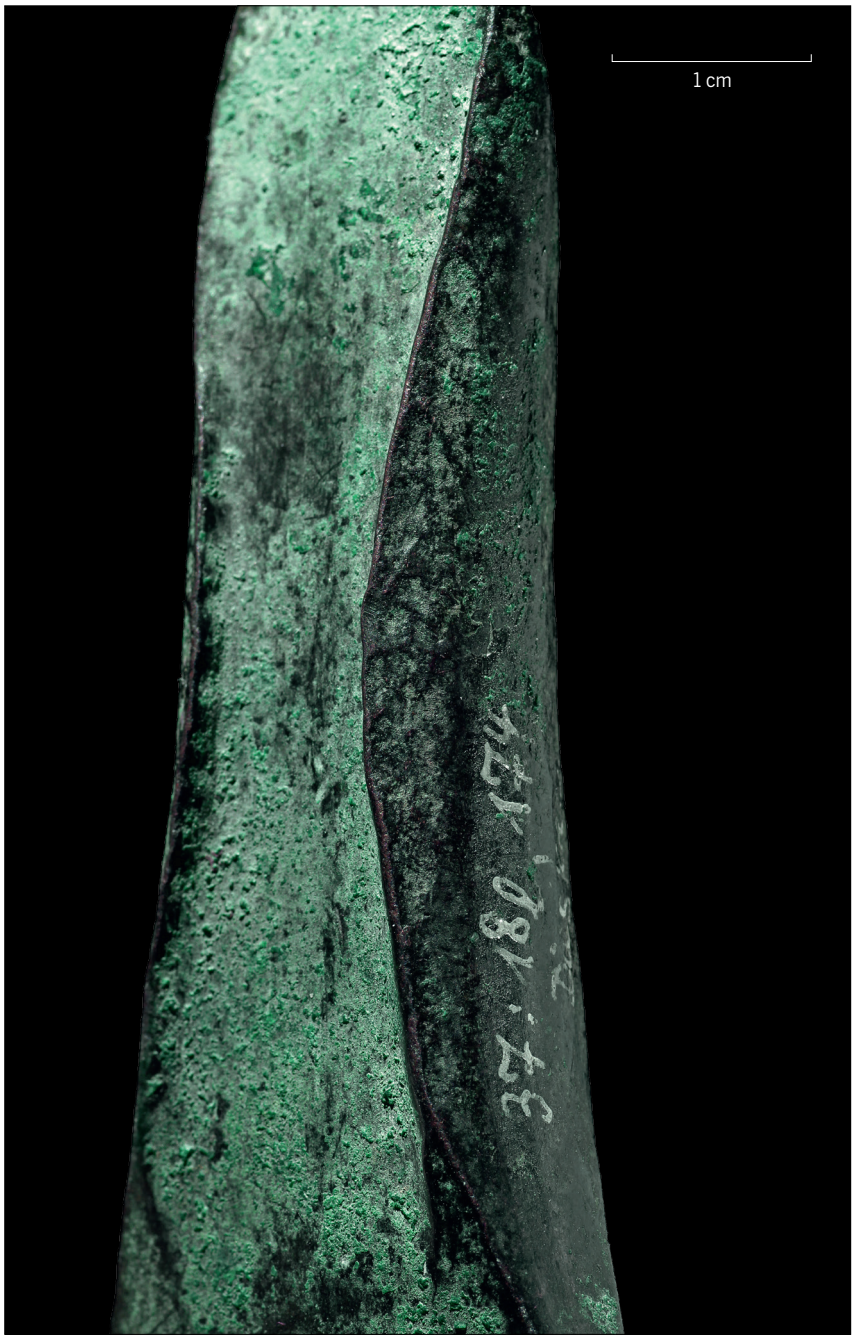


Abb. 10 Bei einer Reihe von Beilen (hier HK 37:18l, 174) sind die Schmalseiten vom Ausschmieden und abschließenden Überschleifen facettiert, zumeist mit drei Facetten.

Fig. 10 *On a number of axes (here HK 37:18l, 174), the narrow sides, having been hammered out and ground, are faceted, usually with three facets.*

3.3 Neue Untersuchungen zur Herstellungstechnik

An den Beilen kann eine Reihe von wiederkehrenden Spuren beobachtet werden. Grundsätzlich ist zu erwähnen, dass an keinem einzigen hier untersuchten Fund eine Gussnaht oder ein Überrest einer solchen Naht erkennbar ist. Bei rund einem Drittel der Beile aus Dieskau III und Halle-Kanena III sowie sehr wenigen weiteren Beilen aus der Mikroregion Dieskau sind die Schmalseiten facettiert (Abb. 10). Die zumeist drei Facetten weisen wahrscheinlich auf ein Ausschmieden und abschließendes Überschleifen hin, das bei diesen Stücken nicht zur Entfernung der Facetten führte (vgl. Billig 1957, 299). An einigen Beilen sind vor allem an den Schmalseiten außerdem Hammerspuren erkennbar. Weiterhin ist zu bemerken, dass rund ein Zehntel der fertiggestellten Beile auf einer oder beiden Seiten in der Bahn eine längs verlaufende, unregelmäßige »Rille« von unterschiedlicher Stärke aufweist, die – sofern vorhanden – auch die Rast durchzieht (Abb. 11). Diese »Rillen« zeigen noch die gussraue Oberfläche des nicht überschmiedeten Rohlings. Sie entstanden, indem der gussraue Rohling zunächst seitlich überschmiedet wurde, um den Schaft auszubilden. Das beim Schmieden verdrängte Material schiebt sich dabei von beiden Seiten her in Richtung Mitte zusammen. Dabei bleibt in einigen Fällen ein schmaler Spalt in der Mitte der Bahn übrig, weil sich das von beiden Seiten dorthin getriebene Metall nicht verschweißen lässt (Abb. 12). Meistens zeigen die Beile nur auf einer Seite diese »Rille«. Dies ist dadurch zu erklären, dass die Rohlinge im Querschnitt nicht symmetrisch waren. Wenn sie in eine offene Form gegossen wurden, war die Oberseite entweder flach oder sogar etwas konkav eingesunken (Erstarrungsschwindung). Die »Rillen«

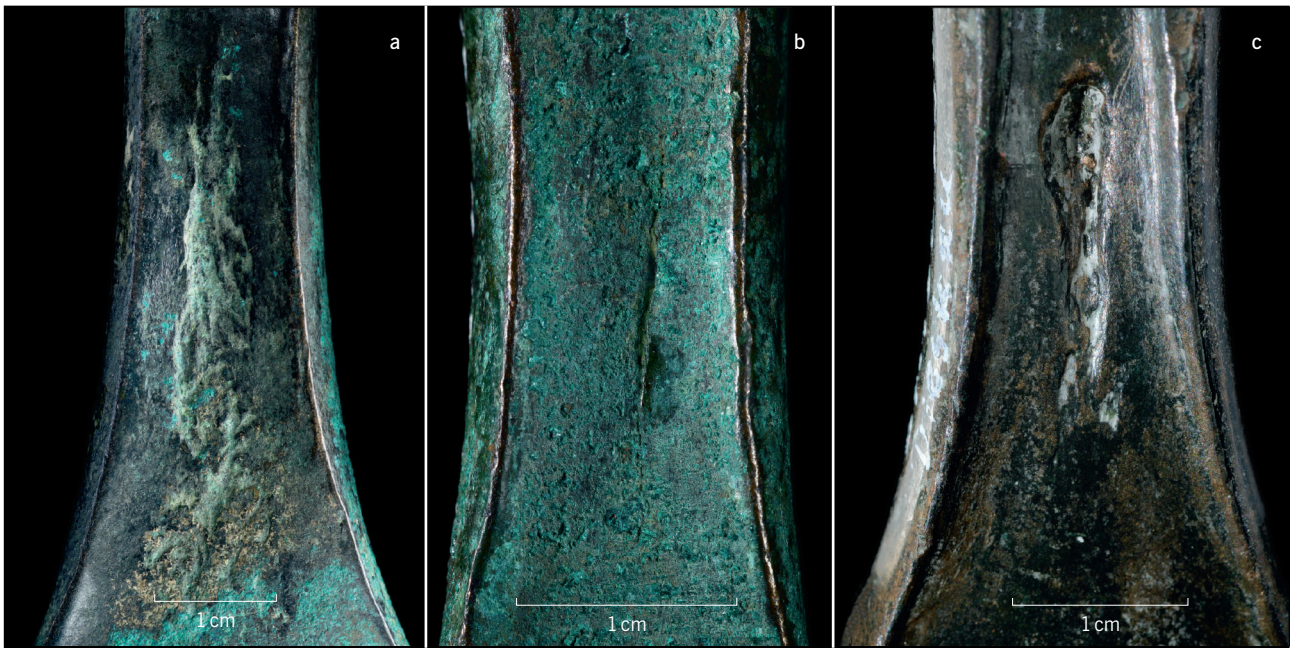


Abb. 11a–c Einige Beile (von links: HK 37:18l, 55, 71 und 290) weisen auf einer oder beiden Seiten in der Bahn eine längs verlaufende, unregelmäßige »Rille» von unterschiedlicher Stärke auf. Sie zeigt in den meisten Fällen noch die Oberflächenstruktur des gegossenen Rohlings. Der Grund ist, dass die alte Oberfläche beim seitlichen Überschmieden noch nicht komplett von dem zur Mitte hin geschmiedeten Material überwachsen wurde.

Fig. 11a–c *Some axes (left to right: HK 37:18l, 55, 71 and 290) show a longitudinal, irregular »groove« of varying thickness on one or both sides of the axe body. In most cases, the surface texture of the cast blank is still visible because the old surface was not fully covered when the material was forged from the sides toward the centre.*

Abb. 12 Mitte und rechts: Zwischenstände eines Versuchs, Randleistenbeile aus einem gegossenen Rohling (links) zu schmieden. Man sieht, dass die rohe Gusshaut in der Mitte des Schaftes erhalten bleibt und wie die in den Beilen anzutreffende tiefe »Rille» in der Bahn entsteht.

Fig. 12 *Right and centre: Intermediate results when trying to forge flanged axes from a cast blank (left). The raw cast skin in the centre of the hafting septum is preserved, and a deep »groove« is created.*

Abb. 13 Gussversuch in offener Form. Beim Erstarren bildet sich eine wellige Oberfläche, wobei sich infolge von Erstarrungskontraktion das Metall in der Mitte konkav zusammenzieht. Oftmals bilden sich schon hierbei längs verlaufende tiefe Spalten aus.

Fig. 13 *Casting trial in an open mould. When the metal solidifies, a wavy surface forms, and the metal contracts concavely in the centre as a result of solidification shrinkage. This often leads to deep longitudinal gaps.*

entstehen bevorzugt auf der konkaven bzw. flachen Seite des Rohlings (Abb. 13)[16].

Der endgültige Nachweis, dass das Ausschmieden der Beile eine sehr wichtige Rolle bei der Formgebung spielte, gelang aber durch die metallografische Untersuchung einer Reihe von früh- bis mittelbronzezeitlichen Bronzebeilen (s. Beitrag Michael u. a. in diesem Band). Sie zeigt unter anderem für zwei Beile aus dem Depot Halle-Kanena III, dass eine wiederholte Bearbeitung mit Warmschmieden und Zwischenglühen notwendig war, um mechanische Festigkeit zu erreichen. Die Bearbeitung betraf nicht nur den Bereich der Klinge, sondern eindeutig auch den Beilkörper und die Randleisten. Der letzte Arbeitsschritt war offenbar ein sorgfältiger Schliff, da die Beile im Allgemeinen zur Gänze fein überschliffen sind.

Damit stellt sich die Frage nach dem Ausgangsmaterial und möglichen Halbfabrikaten der Beilproduktion. Dabei ist davon auszugehen, dass die Form des Rohlings nicht zuletzt von der Metallzusammensetzung und der Masse des Werkstücks abhing, die beide großen Einfluss auf die Schmiedbarkeit haben[17]. Wahrscheinliche Rohlinge und Halbfabrikate können wir in zungen- und beilförmigen »Barren« finden, deren Deutung seit langem diskutiert wird[18]. Zungenförmige Rohlinge von plankonvexem Querschnitt sind im Verbreitungsgebiet der Aunjetitzer Kultur in Mitteldeutschland und Böhmen bekannt (Abb. 14; Liste 2). Sie sind im offenen Herdguss hergestellt und nur wenig bearbeitet. Einen Schlüsselfund stellt das Fundstück aus Freiroda, Burgenlandkreis, dar (s. Abb. 14,1). Schon mit bloßem Auge ist auf der leicht einziehenden Oberfläche des Fundstücks eine wellige Gusshaut zu erkennen (Abb. 15–16). Auf der flachen Oberfläche sind sehr grobe Gefügestrukturen zu sehen, nämlich das Primärgefüge des Gusses. Auf der gewölbten Unterseite sind diese Gefügestrukturen nicht zu sehen, stattdessen aber Gasblasen, die vom Erstarren des Materials herrühren. Dass die Gefügestrukturen so deutlich zu erkennen sind, ist einem Glücksfall zu verdanken: Sie haben sich bei der Bodenlagerung durch korrosive Prozesse, ähnlich einer metallografischen Ätzung, entwickelt. Die Strukturen zeigen, dass die flache Oberseite langsamer als die Unterseite abkühlte. Das ist ein Hinweis darauf, dass sie beim Erstarren an der Luft lag, wodurch die Wärme

16 Für diese Hinweise danken wir dem Kupferschmied H. R. Bauer, Halle (Saale). Billig beschreibt ähnliche Spuren an einem fundortlosen Beil aus dem Stadtmuseum Meißen und deutet sie ebenfalls als Hinweis auf ein Ausschmieden der Randleisten (Billig 1957, 299; Billig 1958, 157 f. Abb. 95,3).

17 Freundlicher Hinweis H. R. Bauer, Halle (Saale).

18 Szombathy 1890, [18]; von Brunn 1950, 241; Hundt 1975, 117–119; Mayer 1977, 78 f.; Billig 1961, 101; Moucha 2005, 43; Kienlin 2008, 257 Anm. 703. – Zu nennen sind in diesem Zusammenhang auch die im Querschnitt spitzovalen, nur geringe Zinngehalte aufweisenden zungenförmigen »Barren« aus verschiedenen frühmittelbronzezeitlichen Hortfunden im Karpatenbecken, die ebenfalls das Ausgangsmaterial für Randleisten- oder frühe Absatzbeile darstellen könnten (Mozsolics 1967, 96–98; vgl. Krause 2003, CD-Rom; Găvan 2015, 62). Die beilförmigen »Barren« vom Typ Niederosterwitz, die an den Schmalseiten einen dachförmigen Grat aufweisen, nur unwesentlich nachbearbeitet sind und offenbar aus Zinnbronze bestehen, sind in ihrer Funktion umstritten. Aufgrund der vorhandenen Gussnähte wurden sie – zum Teil mehrere Exemplare gleichzeitig – im Zweischalenguss hergestellt. Sie sind hauptsächlich im südlichen Mitteleuropa verbreitet und datieren in die späte Früh- und frühe Mittelbronzezeit (Mayer 1977, 66–71; Krause 2003, CD-Rom; Kienlin 2008, 257 Anm. 703; Kienlin 2010a, 148; vgl. Kuijpers 2018, 183). Auf jeden Fall weichen die zungen- und beilförmigen »Barren« aus dem Aunjetitzer Raum eindeutig von diesen Formen ab. Sehr wahrscheinlich unterlag die Herstellung von Beilen zeitlichen und regionalen Veränderungen.

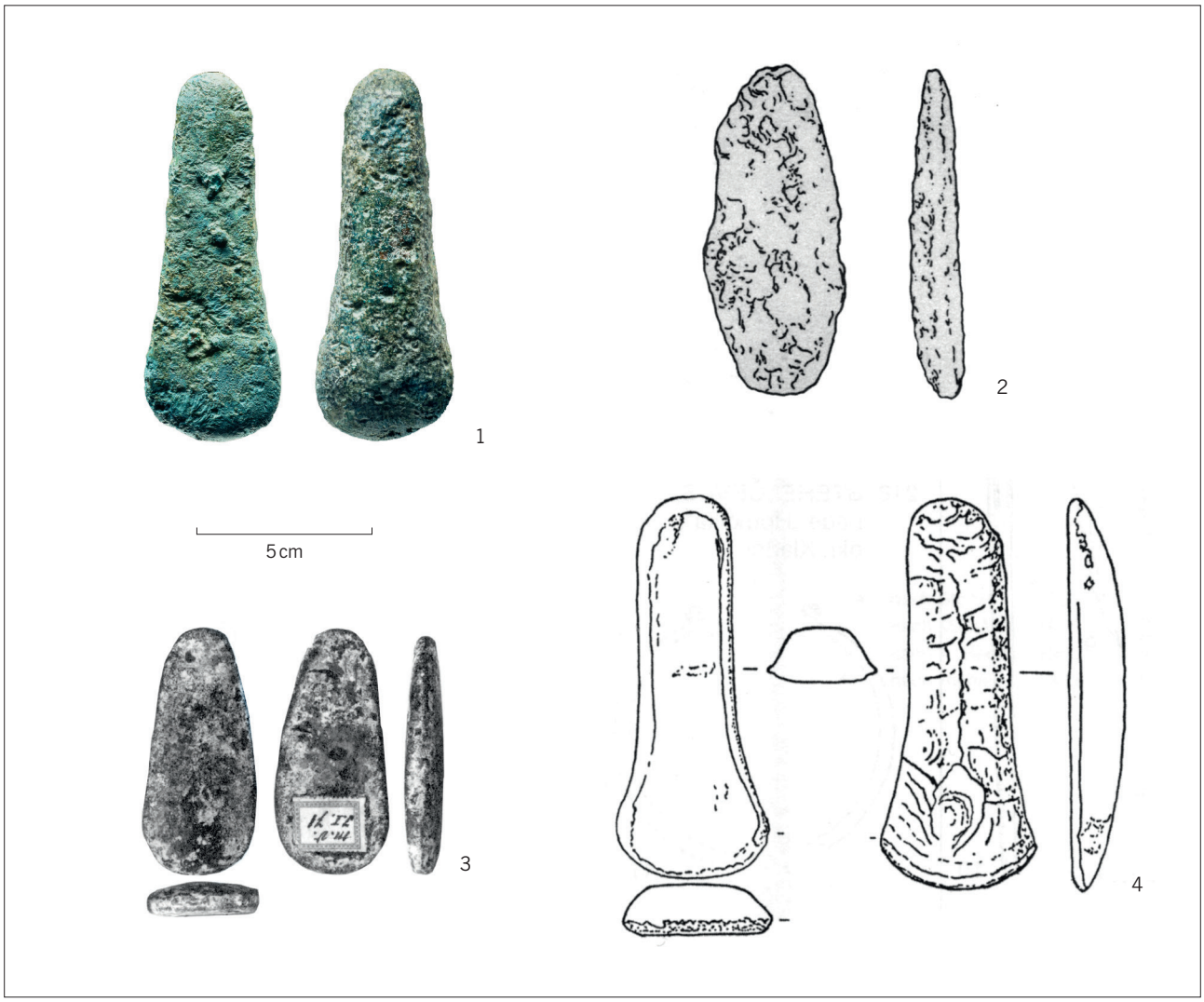


Abb. 14 Zungenförmige Rohlinge mit plankonvexem Querschnitt. 1 Freiroda, Burgenlandkreis; 2 Dresden-Dobritz; 3 Dolánky, okr. Louny (Tschechische Republik); 4 Hříškov, okr. Louny (Tschechische Republik).

Fig. 14 *Tongue-shaped cast blanks with a plano-convex cross-section. 1 Freiroda, Burgenlandkreis district; 2 Dresden-Dobritz; 3 Dolánky, okr. Louny (Czech Republic); 4 Hříškov, okr. Louny (Czech Republic).*

nur langsam abgeführt wurde und der Erstarrungsprozess verzögert war. Die Unterseite erstarrte schneller, weil das Formbaumaterial eine größere Wärmeleitfähigkeit und -kapazität hatte als Luft. Nimmt man an, dass es sich hier um die »Urform«, also den Rohling eines Beiles handelt, wird klar, warum Beilgießformen aus der Aunjetitzer Kultur nur vereinzelt erhalten sind: Es genügte, in feuchte Erde, Lehm, Formsand o. ä. mit einem Model oder auch dem Daumen eine längere Mulde zu drücken, die Form trocknen zu lassen und dann das Metall einzugießen. Die weitere Formgebung entstand anschließend durch das Schmieden, wodurch das Material auch die erforderliche Festigkeit erhielt.

Aus denselben Regionen liegen trapez- oder beilförmige Stücke mit symmetrischem Querschnitt vor, deren Kanten relativ glatt sind und Schmiedespuren zeigen (Abb. 17; Liste 3). Die Schneiden sind jedoch stumpf. Während H.-J. Hundt sie als Hämmer deutet (Hundt 1975, 117–119), handelt es sich angesichts der Nachweise für das Ausschmieden der Beile mit großer Wahrscheinlichkeit um Halbfabrikate, die entweder aus den zungenförmigen Rohlingen oder anderen Formen gearbeitet worden sind (vgl. Billig 1961, 102; Kuijpers 2018, 184). Markante Beispiele sind die Stücke aus Naumburg (s. Abb. 17,5) und Schkopau (s. Abb. 17,7). Beide sind trapezförmig in der Frontansicht und linsenförmig mit abgestumpften Ecken in der Seitenansicht. Unter dem Mikroskop weisen sie eine unauffällige Oberfläche auf. Das Stück aus Naumburg ist glatt, während das aus Schkopau anscheinend im Rahmen einer früheren Restaurierung von Korrosion befreit wurde und daher eine metallische, etwas narbige Oberfläche aufweist. Die Schneiden sind stumpf, weder ausgeschmiedet noch geschliffen, und bilden eine glatte und leicht gewölbte Fläche mit einer Breite von etwa 0,5 cm. Bei beiden sind die Kanten andeutungsweise etwas hochgezogen, als ob es sich um Ansätze von Randleisten handelt. Der Fund aus Naumburg hat im vorderen Bereich in der Nähe der Schneide einen quer verlaufenden feinen Spannungsriss. Die Oberflächen zeigen keine Werksspuren, außer auf der Rückseite des Stücks von Schkopau im Bereich der Schneide. Diese sind jedoch kaum zu erkennen und haben nichts mit einem Schärfungsprozess zu tun, da

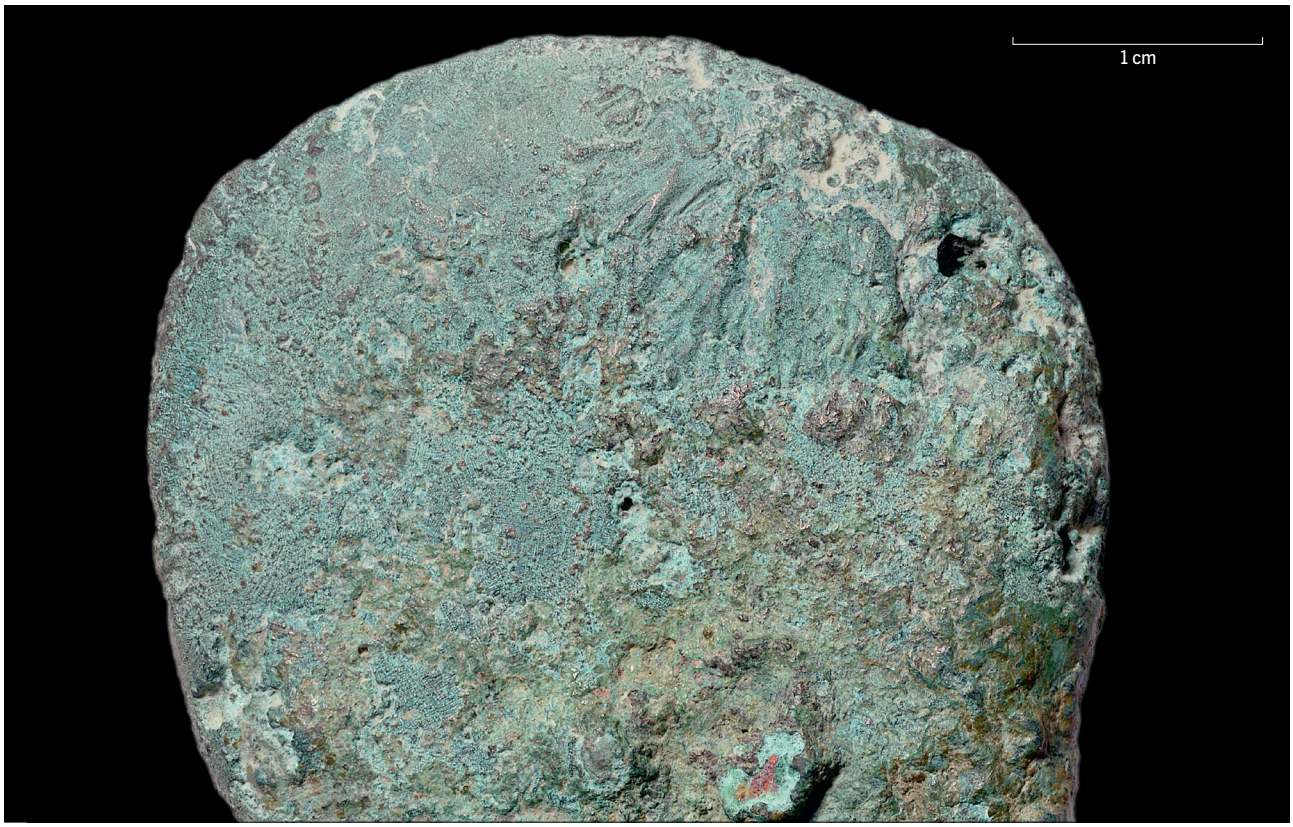


Abb. 15 Freiroda, Burgenlandkreis. Oberseite, vorderes Ende. Deutlich zu erkennen sind die gefaltete Gusshaut und das nach dem Guss unveränderte Metallgefüge.

Fig. 15 *Freiroda, Burgenlandkreis district. Upper side, front end. The folded cast skin and the metal structure that remained unchanged after casting are clearly visible.*

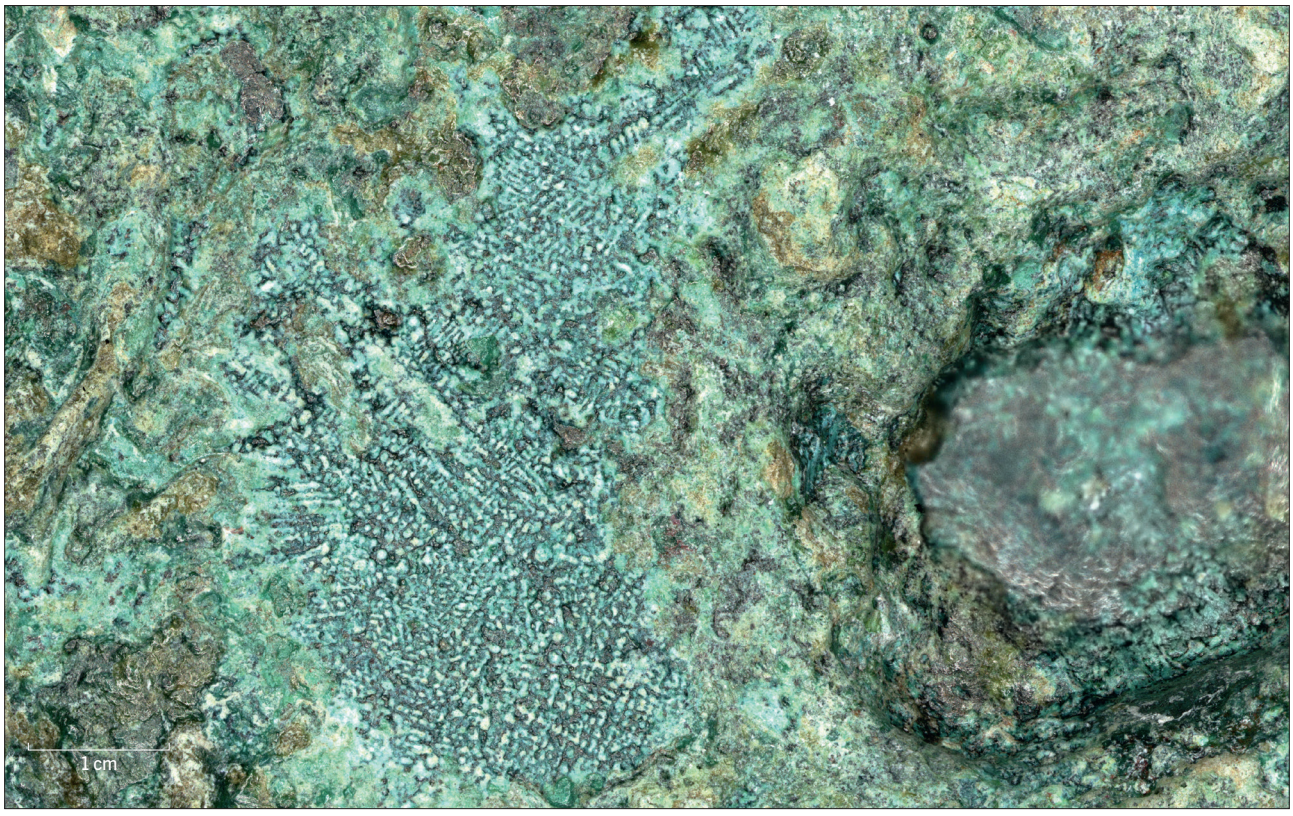


Abb. 16 Freiroda, Burgenlandkreis. Mikroskopische Aufnahme. Die grobe Gussstruktur ist deutlich zu erkennen.

Fig. 16 *Freiroda, Burgenlandkreis district. Microscopic image. The coarse cast structure is clearly visible.*

Abb. 17 Trapez- bzw. beilförmige Halbfabrikate. 1 Dermsdorf, Lkr. Sömmerda; 2 Meineweh, Burgenlandkreis; 3–4 Milzau-Burgstaden, Saalekreis; 5 Naumburg, Burgenlandkreis; 6 Oldisleben, Kyffhäuserkreis; 7 Schkopau, Saalekreis; 8 Nieder Neundorf, Lkr. Görlitz; 9 Straubing (Bayern); 10 Jičíněves, okr. Jičín (Tschechische Republik); 11 Očihov, okr. Louny (Tschechische Republik); 12 Soběchleby, okr. Louny (Tschechische Republik).

Fig. 17 *Trapezoidal and axe-shaped semi-finished products. 1 Dermsdorf, Sömmerda district; 2 Meineweh, Burgenlandkreis district; 3–4 Milzau-Burgstaden, Saalekreis district; 5 Naumburg, Burgenlandkreis district; 6 Oldisleben, Kyffhäuserkreis district; 7 Schkopau, Saalekreis district; 8 Nieder Neundorf, Görlitz district; 9 Straubing (Bavaria); 10 Jičíněves, okr. Jičín (Czech Republic); 11 Očihov, okr. Louny (Czech Republic); 12 Soběchleby, okr. Louny (Czech Republic).*

die Schneide immer noch stumpf ist. Dabei kann das Naumburger Produkt als Zwischenstufe zwischen den Freirodaer und dem Schkopauer Exemplaren angesehen werden: Naumburg hat noch die konvexe Form der Unterseite wie das Freirodaer Exemplar, während das Schkopauer Exemplar auf beiden Seiten plan ist. Letzteres trägt auch schon eine seitliche Facettierung und leichte Ansätze von Randleisten.

Abb. 18 Burgstaden-Milzau, Saalekreis. Mikroskopische Aufnahme. Quer durch das unregelmäßig geformte mutmaßliche Halbfabrikat zieht sich ein »Ermüdungsriss», der wohl von unsachgemäßem Schmieden verursacht wurde.

Fig. 18 *Milzau-Burgstaden, Saalekreis district. Microscopic image. A »fatigue crack,« probably caused by inexpert forging, runs across the irregularly shaped, presumedly semi-finished product.*

Ein etwas zweifelhafteres Halbfabrikat stellt das zungenartige Metallstück aus Milzau-Burgstaden, Saalekreis, dar (s. Abb. 17,4). Es hat eine zungenartig unregelmäßige Form mit abgerundeten Rändern, die beim Ausgießen und Erstarren einer Metallmasse entstehen, wenn sie beispielsweise in eine längliche, flache Mulde gegossen wird. Sowohl die Vorder- als auch die Rückseite sind relativ plan, abgesehen von tieferliegenden Löchern. Im Streiflicht sind Eindrücke wie Hammerspuren sichtbar. Quer über die Oberfläche verläuft etwa in der Mitte des Objekts ein ca. 0,5 mm breiter »Ermüdungsriss« (Abb. 18). Unter dem Mikroskop sind in der Metalloberfläche keine Gefügestrukturen erkennbar. Es sind nur wenige diagonale Schleifspuren zu sehen. Das Stück aus Milzau-Burgstaden ist offenbar ein durch flaches Überschmieden verdichteter Rohguss (oder nur Tiegelausguss?), wobei tief in der Oberfläche liegende Poren bzw. Gasblasen noch nicht vom Hammer erfasst wurden. Möglicherweise handelt es sich um den Versuch, den Metallrest aus einem Tiegel noch zu einem Beil zu schmieden, was jedoch aufgegeben wurde, als das Werkstück riss.

Außerdem liegen in einigen Hortfunden in Mitteldeutschland, aber auch darüber hinaus Halbfabrikate in einem fortgeschrittenen Produktionsstadium vor. Im Hort Dieskau III betrifft dies lediglich ein Fundstück, im Hort Gröbers-Bennewitz I zwei Fundstücke und im nur teilweise überlieferten Hort Schkopau eine nicht näher bezifferbare Anzahl. Vor allem der Hort Halle-Kanena III enthält neben guten Beilen eine Reihe von nicht vollständig ausgeformten Stücken (Abb. 19). Einige davon weisen ein auffällig niedriges Gewicht auf, sind porös gegossen und wirken eher wie Fehlgüsse[19]. Dies wird durch die Röntgenaufnahmen gestützt. Exemplarisch wurden das einzige Beil aus Dieskau II, 22 Beile aus Dieskau III und vier Beile aus Halle-Kanena III geröntgt (Abb. 20)[20]. Dabei ist deutlich erkennbar, dass die Dieskauer Beile im Allgemeinen eine sehr dichte Struktur aufweisen und nur in Einzelfällen noch im Nacken- (HK 37:18l, 220 sowie 226, 283, 285) oder Klingenbereich (HK 37:18l, 95 sowie 272, 285, 290) Lunker bzw. Gasblasen aufweisen. Hingegen ist die Struktur der Beile aus Halle-Kanena III mit Ausnahme eines Stücks (HK 34:305 o, 4) auf ganzer Länge stark porös (HK 34:305 l, 26 sowie 30, 35). Außerdem sind vier ausgeschmiedete Halbfabrikate aus dem Hort von Dermsdorf zu nennen[21]. Auch außerhalb des Aunjetitzer Kulturraums stehen manche Objekte im Verdacht, lediglich Halbfabrikate zu sein (Mayer 1977, 78 f.). So könnte jeweils ein Fundstück aus den Hortfunden Sennwald-Salez, Schweiz (Abels 1972, 8 Nr. 76; vgl. Kienlin 2008, 55; 143), und Böhringen-Rickelshausen, Lkr. Konstanz (Abels 1972, 7 Nr. 62), entsprechend gedeutet werden. Das Randleistenbeil von Güglingen, Lkr. Heilbronn (Abels 1972, 7 Nr. 64), wurde wohl ebenfalls nicht zu Ende geschmiedet. Nur eine Seite der Schneide und eine Randleiste sind im Gegensatz zur anderen Seite vollendet. Das Stück weist zugleich einen starken Gussfehler auf, der vielleicht zu seiner Verwerfung führte (Kuijpers 2018, 179–181). Auch ein Beil von unbekanntem Fundort ist nicht komplett fertiggestellt, aber zur Gänze überschliffen worden (Mayer 1977, 78 Nr. 245; Kuijpers 2018, 184).

Gießformen für Randleistenbeile waren in Mitteldeutschland bis vor kurzem nicht bekannt. Vor wenigen Jahren wurde aber bei Tultewitz, Stadt Naumburg, Burgenlandkreis, ein Bruchstück aus Sandstein mit einem konkaven Einzug von 6 mm Tiefe und 22–28 mm Breite entdeckt, das zu einer Form für ein Beil gehört (Abb. 21; s. Beitrag Dalidowski u. a. in diesem Band). Es bildet einen Teil der Bahn ab, wobei keine Randleisten im Negativ angelegt sind. Die rötliche Hitzeverfärbung belegt die Verwendung zum Metallguss. Das Fundstück stammt aus einer Siedlungsgrube, die anhand der Keramik in die späte Aunjetitzer Kultur (Stufe AK 4) datiert werden kann (Schwarz 2021)[22].

19 Vgl. zu Gussqualitäten Kuijpers 2018, 113–116.

20 Die Röntgenuntersuchungen führte dankenswerterweise H. Breuer, LDA Halle, durch.

21 Vgl. Küßner/Wechler 2019, 449–457. Als Halbfabrikate können folgende Stücke bezeichnet werden: Küßner/Wechler 2019, 451 Inv.-Nr. 11/101-9. 11. 13; 452 Inv.-Nr. 11/101-70.

22 Wir danken der Projektkoordinatorin X. Dalidowski und J. Kleinecke, beide LDA Halle, für die Meldung und Auskünfte sowie R. Schwarz, LDA Halle, für die genaue chronologische Einordnung.

Abb. 19a–f Aus manchen Horten, vor allem Halle-Kanena III (a–e), in einem Fall aber auch aus Dieskau III (f), liegen neben fertigen und teils benutzten Beilen auch Halbfabrikate (a–f) vor.

Fig. 19a–f *Some hoards contain finished and partially used axes but also semi-finished products (a–f), such as Dieskau III with one semi-finished product (f) and especially Halle-Kanena III (a–e).*

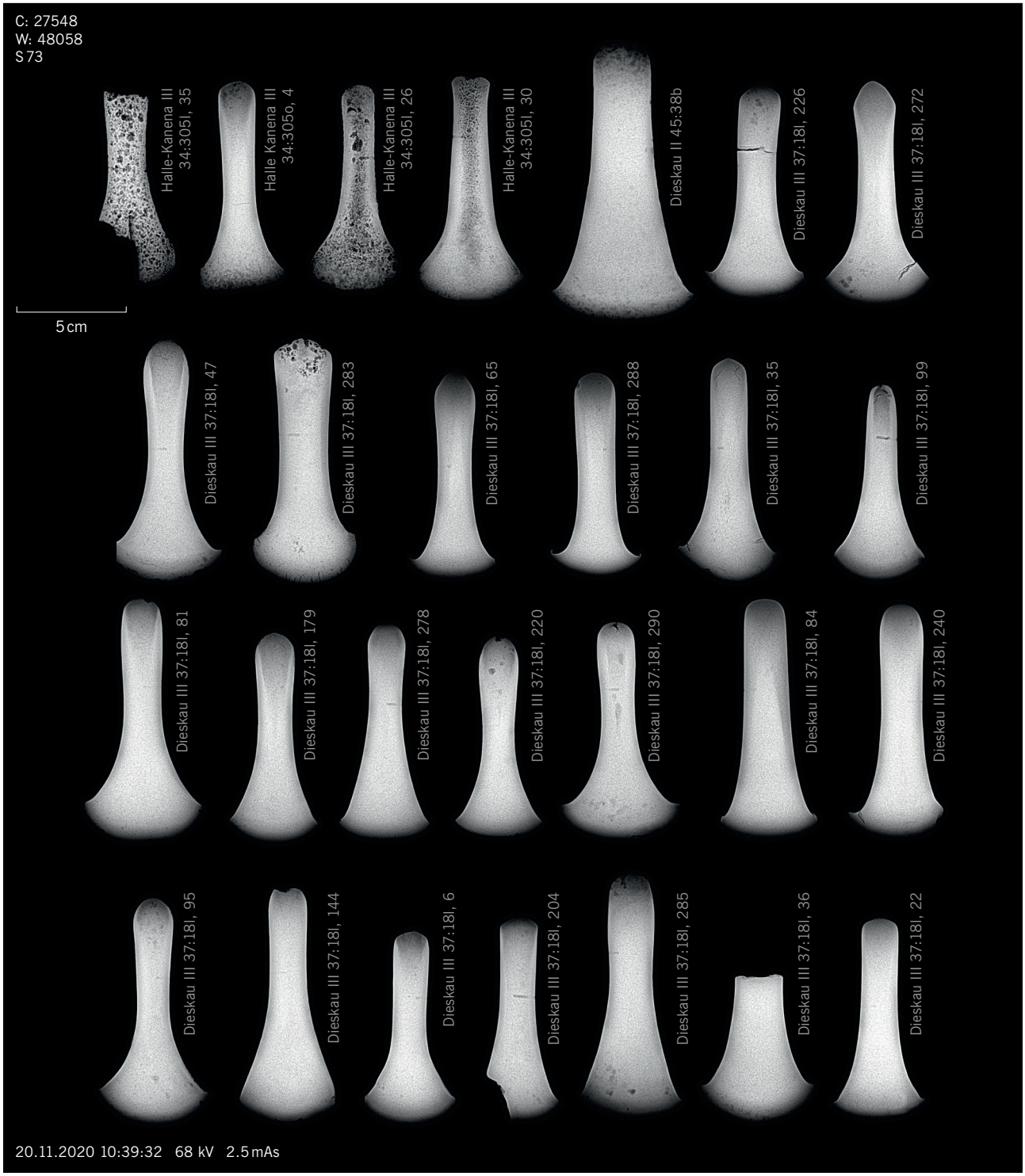


Abb. 20 Röntgenaufnahme von Beilen der Hortfunde Dieskau II, Dieskau III und Halle-Kanena III, alle Saalekreis.

Fig. 20 *X-ray image of axes from the hoards of Dieskau II, Dieskau III, and Halle-Kanena III, all Saalekreis district.*

Aus Böhmen liegen insgesamt vier frühbronzezeitliche einteilige, offene Gießformen für »Zungenbarren« bzw. »Beilbarren« vor (Abb. 22). Aus Lovosice, okr. Litoměřice (Tschechische Republik), ist eine Gießform aus Lehm für einen »Zungenbarren« mit einer Länge von 130–140 mm und maximal 14 mm Tiefe bekannt (Blažek u. a. 1998, 164 f. Nr. 98). Aus Vraný, okr. Kladno (Tschechische Republik), liegt eine Tonform mit einem Negativ für einen ca. 95 mm langen »Zungenbarren« vor (Blažek u. a. 1998, 181 Nr. 144). Eine Tonform mit dem Negativ eines »Beilbarrens« stammt aus Hosty, okr. Česke Budějovice (Tschechische Republik) (Blažek u. a. 1998, 191 Nr. 174). Die tönerne Gießform von Praha-Vysočany (Tschechische Republik) ist schüsselförmig mit einem dreieckigen Negativ für einen beilförmigen »Barren«, von dem ein Kanal zum Rand der Form verläuft (Blažek u. a. 1998, 173 f. Nr. 121).

Außerhalb des Aunjetitzer Kulturraums liegt ein rechteckiger Block aus Sandstein aus Landershausen, Lkr. Hers-

Abb. 21 Die fragmentarische Gießform aus Sandstein von Tultewitz, Burgenlandkreis, wurde in einer Siedlungsgrube entdeckt. In ihr konnten Rohlinge für Randleistenbeile gegossen werden. Die hitzebedingte rötliche Verfärbung belegt ihren Gebrauch.

Fig. 21 *The fragmentary sandstone mould from Tultewitz, Burgenlandkreis district, was discovered in a settlement pit. It could be used for casting blanks for flanged axes. The heat-induced reddish discolouration proves that it had indeed been used.*

feld-Rotenburg (Hessen), vor, der auf beiden Flachseiten je ein Negativ für einen Beilrohling mit Eingusstrichter enthält. Es handelt sich daher nicht um offene Formen, aber die Gegenstücke fehlen. Hitzebedingte Verfärbungen belegen den Gebrauch als Gießformen (Sattler 2016). Weiterhin sind aus Süddeutschland einige weitere Gießformbruchstücke aus Sandstein für »beilförmige Barren«, die sicherlich vielfach Rohlinge für Randleistenbeile darstellen[23], vom Übergang von der Früh- zur Mittelbronzezeit bekannt (Overbeck 2018, 130–139). Gießformen mit eindeutig angelegten Randleisten datieren aber anscheinend bereits in etwas jüngere Phasen der Mittelbronzezeit (Mayer 1977, 102 f.; 105; Overbeck 2018, 138).

Es ist also durchaus vorstellbar, dass die Rohlinge in der Regel im offenen oder verdeckten Herdguss in ähnlichen Gießformen hergestellt wurden[24]. Die Orientierung der Formen beim Guss bleibt für eine größere Serie zu untersuchen. Bislang weisen nur wenige Stücke eine erhöhte Porosität am Nacken auf, die auf eine aufrechte Position der Gießform hindeuten könnte (vgl. Kienlin 2010, 825–828). Wie jedoch z. B. die in derselben zweiteiligen Gießform hergestellten »anglo-irischen« Beile von Griefstedt, Lkr. Sömmerda, zeigen, existieren auch Ausnahmen vom Herdguss (s. u.; Billig 1957, 290; 296) (s. u. Abb. 34,4–5). Auch im Hort von Dermsdorf sind einzelne Fundstücke, die keine typischen Sächsischen Randleistenbeile repräsentieren, offenbar mit bereits angelegten Randleisten gegossen worden (Küßner/Wechler 2019, 451 Inv.-Nr. 11/101-1; 453 Inv.-Nr. 11/101-91; 455).

3.4 Neue Untersuchungen zu Gebrauchsspuren und Funktion

Im Laufe der Zeit sind die Beile als Werkzeuge, Waffen, frühe Form von Geld bzw. Wertmaßstäbe, Barren und sogar als Mittel zur Klangerzeugung gedeutet worden (s. o.). Gegen eine Deutung der Sächsischen Randleistenbeile als reine Barren, Geldform oder Wertmaßstäbe spricht die relativ aufwendige Herstellungstechnik, die nach dem Guss des Rohlings ein intensives Ausschmieden erforderte. Außerdem weisen die Beile zahlreiche Gebrauchsspuren auf (vgl. Billig 1961; Kienlin 2008, 299 f.). Diese widersprechen auch einer Nutzung der Beile als »Musikinstrumente« (vgl. auch Eichmann 2015, 205).

23 Overbeck 2018, 133 Nr. 47–48; 134 Nr. 50–53; 135 f. Nr. 58; 177 Nr. 132.

24 Die von Billig als Belege für Zweischalenguss angeführten Beile von Jessen-Wauden, Lkr. Wittenberg, und Halle-Bruckdorf zeigen keine zwingenden Befunde für diese Deutung, wie z. B. Überreste von Gussnähten (vgl. Billig 1957, 299).

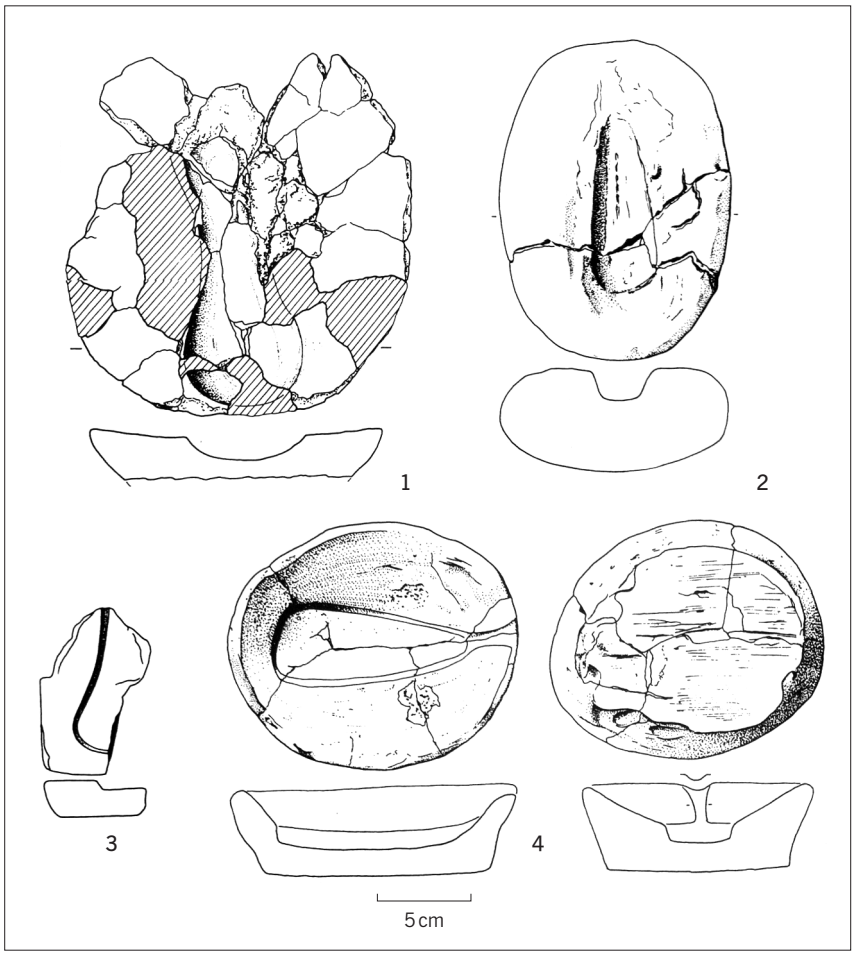


Abb. 22 Einteilige, offene Gießformen für zungen- bzw. beilförmige Rohlinge aus Böhmen. 1 Lovosice, okr. Litoměřice; 2 Vraný, okr. Kladno; 3 Hosty, okr. Česke Budějovice; 4 Praha Vysočany (alle Tschechische Republik).

Fig. 22 *One-piece open moulds for tongue- or axe-shaped cast blankets from Bohemia. 1 Lovosice, okr. Litoměřice; 2 Vraný, okr. Kladno; 3 Hosty, okr. Česke Budějovice; 4 Praha Vysočany (all Czech Republic).*

Die Gewichte sind entscheidend für die Frage, ob die Beile überhaupt theoretisch als Wertmaßstäbe in Frage kommen (vgl. Lenerz-de Wilde 1995). Betrachtet man die Gewichtsverteilung der Beile in den Horten der Mikroregion Dieskau, ist nur für Dieskau III ein einzelner Peak bei 130 g feststellbar, während die Verteilung in den übrigen Deponierungen mehrere Peaks zeigt (Abb. 23). Diese Unterschiede zeigen sich auch, wenn die Mittel- mit Medianwerten verglichen werden (Tab. 3). Lediglich bei Dieskau III weichen beide Parameter nur minimal voneinander ab. Von großer Bedeutung ist die Berücksichtigung der menschlichen Wahrnehmung von Gewichten und der Schwelle, von der an Unterschiede wahrgenommen werden. Hierzu existieren psychophysische Untersuchungen, die mit dem Namen des Physiologen und Anatoms E. H. Weber verbunden sind. Man geht davon aus, dass der Schwellenwert bei ± 10 % des Gewichts liegt (Kuijpers/Popa 2021, 10 f.).

Wie von Kuijpers und Popa vorgeschlagen, wurden die Beile der vorliegenden Hortfunde auf Gewichtsähnlichkeiten unter Berücksichtigung dieser Wahrnehmbarkeitsschwelle getestet (Kuijpers/Popa 2021) (Abb. 24; Tab. 7)[25]. Es stellt sich heraus, dass 43,6 % der Beile von Dieskau III zwischen 119,4 g und 146,0 g wiegen und gewichtsmäßig wie ein Beil von 132,7 g wahrgenommen worden wären. Von den erhaltenen Beilen aus Schkopau wiegen 40,0 % zwischen 182,7 g und 223,3 g und würden einem Beil von 203,0 g entsprechen. Bei Halle-Kanena III wiegen 36,2 % der Beile zwischen 97,2 g und 118,8 g und wären von einem Beil von 108,0 g Gewicht nicht unterscheidbar. Die Beile von Gröbers-Bennewitz I wiegen zu 75,6 % zwischen 301,5 g und 368,5 g und würden einem Beil von 335,0 g Gewicht entsprechen. Das von Kuijpers und Popa festgestellte »Standardgewicht« bei Ösenringen, Spangenbarren und z. T. Beilen von 195,5 g weicht damit deutlich von den sich unterscheidenden Standards der vorliegenden Beilhorte ab (Kuijpers/Popa 2021, 9). Insofern ist auszuschließen, dass die Beile überregional genormte Wertmaßstäbe repräsentieren. Gleichwohl stellten sie – besonders in hoher Anzahl – sicherlich einen bedeutenden Wert dar. Die vorliegenden Gewichtsähnlichkeiten innerhalb der einzelnen Hortfunde sind wahrscheinlich das Resultat einer standardisierten Herstellung aus mehrheitlich sehr ähnlichen Rohlingen und untermauern eine regelmäßige gemeinsame bzw. zentralisierte Produktion der Beile.

Gegen die Funktion als »Barren« spricht auch die aufwendige Bearbeitung. Sollte nur das Metall an sich im Vordergrund stehen, wäre der komplexe Schmiedeprozess unnötig gewesen. Das Schmieden dient vor allem dazu, das Metall zu verfestigen, um es anschließend schärfen und als Beil verwenden zu können.

25 Die Berechnungen wurden mithilfe eines vergleichenden Algorithmus im Statistikprogramm R (Version 4.3.2) durchgeführt.

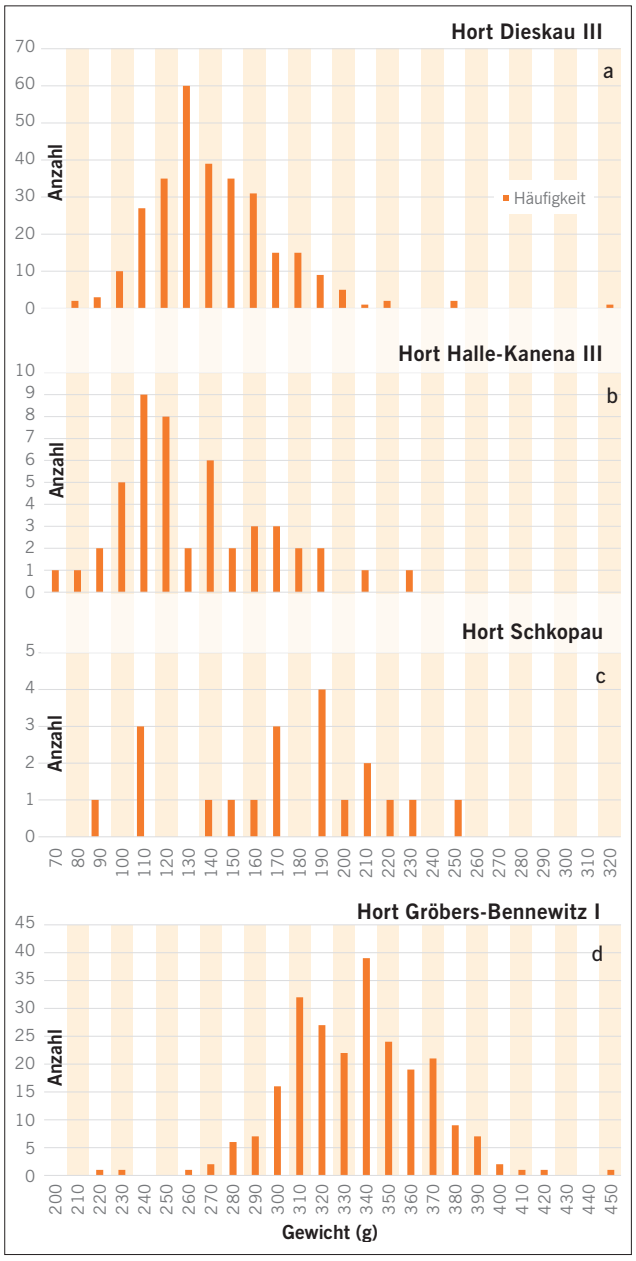


Abb. 23a–d Histogramm der Gewichte von Beilen aus den Hortfunden Dieskau III (a), Halle-Kanena III (b), Schkopau (c) und Gröbers-Bennewitz I (d).

Fig. 23a–d *Histogram of the axe weights from the hoards of Dieskau III (a), Halle-Kanena III (b), Schkopau (c), and Gröbers-Bennewitz I (d).*

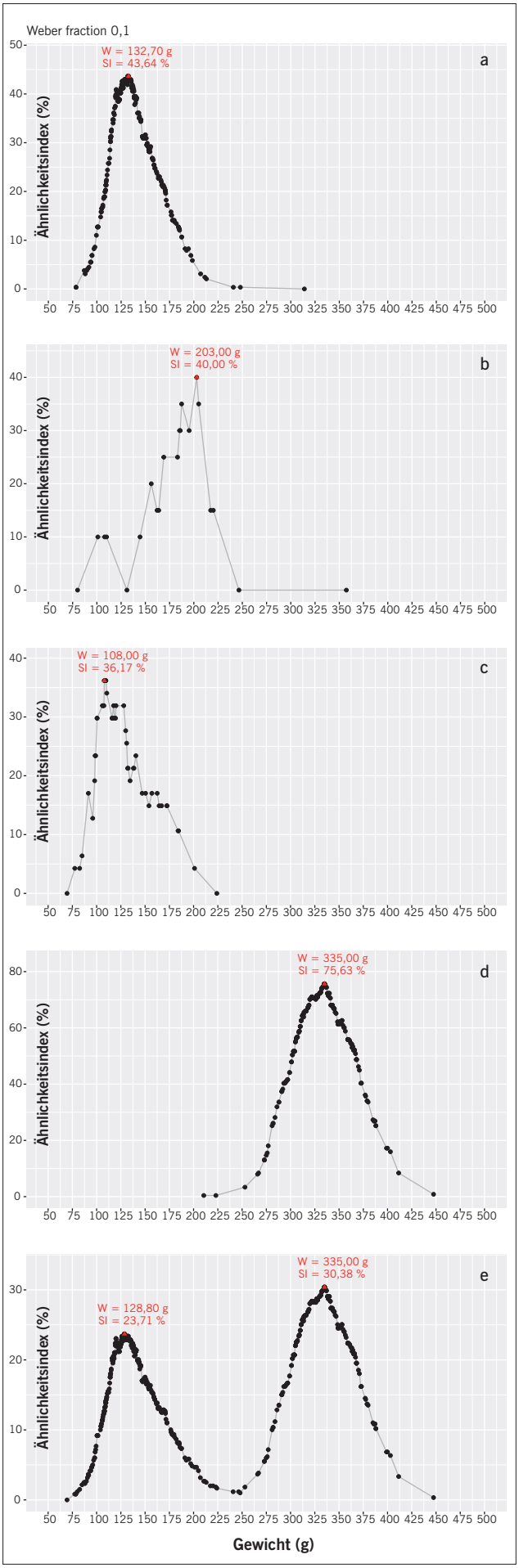


Abb. 24a–e (rechts) Ähnlichkeitsindices der Gewichte von Beilen in den Hortfunden Dieskau III (a), Halle-Kanena III (b), Schkopau (c), Gröbers-Bennewitz I (d) sowie für alle Beile aus den genannten Horten (e). Auf der Y-Achse aufgetragen ist der Prozentsatz der Stücke, die unter Berücksichtigung einer Wahrnehmbarkeitsschwelle von ± 10 % von einem Beil mit einem bestimmten Gewicht (X-Achse) gewichtsmäßig nicht zu unterscheiden sind. Jeder schwarze Punkt entspricht einem Beil. Die höchste Übereinstimmung (SI) wäre jeweils bei einem Stück mit dem rot angegebenen Gewicht (W) erreicht (vgl. Kuijpers/Popa 2021).

Fig. 24a–e (to the right) *Similarity indices of the axe weights from the hoards of Dieskau III (a), Halle-Kanena III (b), Schkopau (c), Gröbers-Bennewitz I (d), and all of them together (e). The percentage of the specimens whose weight cannot be distinguished from an axe of a certain weight (x-axis), taking into account a perceptibility threshold of ± 10%, is plotted on the y-axis. Each black dot corresponds to an axe. The highest correspondence (SI) would be achieved in each case with a piece of the weight indicated in red (W) (see Kuijpers/Popa 2021).*

Hort	Anzahl der gewogenen Beile	Ähnlichkeitsindex Durchschnitt	Ähnlichkeitsindex Maximum	Gewicht bei höchster Ähnlichkeit (g)	Durchschnitt Gewicht (g)
Dieskau III	292	29,57	43,64	132,70	137,40
Halle-Kanena III	48	21,63	36,17	108,00	127,83
Schkopau	21	17,62	40,00	203,00	176,76
Gröbers-Bennewitz I	239	55,85	75,63	335,00	330,20

Tab. 7 Ergebnisse der Berechnung der Ähnlichkeitsindices der Beilgewichte.

Tab. 7 *Results of the calculation of the similarity indices of the axe weights.*

Hinsichtlich der Gebrauchsspuren ist ihre Ähnlichkeit innerhalb der einzelnen Fundkomplexe bemerkenswert. Im Folgenden werden die drei vollständig aufgenommenen Horte Dieskau III, Halle-Kanena III und Gröbers-Bennewitz I verglichen (Abb. 25). Die Beile von Dieskau III wurden zu 52 % durch Überschmieden und Schleifen intensiv nachgeschärft. Bei 14 % der Stücke finden sich auf der Klinge auch Schmiedespuren, die offenbar nicht hinreichend überpoliert worden sind. Auch die immer wieder zu beobachtende Auszipfelung der Schneidenecken ist durch intensives Nachschmieden bedingt (Billig 1957, 300 Anm. 21). Des Weiteren sind bei 49 % der Beile nicht reparierte Scharten und ähnliche kleine Beschädigungen der Schneide zu beobachten, während noch bei 9 % überarbeitete Scharten u. ä. erkennbar sind. Rund 3 % der Beile weisen Risse oder Brüche in der Bahn auf. Insgesamt sind zahlreiche Beile aus dieser Deponierung stark abgenutzt und nachbearbeitet, sodass mehrheitlich von einer längeren Nutzungsdauer auszugehen ist (Abb. 26).

Hingegen wirken die Beile von Halle-Kanena III im Durchschnitt weniger abgenutzt. Knapp 19 % der Stücke sind sogar unvollständig ausgeformte Beile, die offenbar nicht fertiggestellt und verwendet worden sind. Möglicherweise handelt es sich hierbei teilweise um Fehlgüsse, deren Weiterbearbeitung irgendwann abgebrochen wurde (s. o.). Eine intensive Nachschärfung ist für 31 % der Beile zu konstatieren. Frische Beschädigungen an der Schneide weisen 21 %, überarbeitete Scharten nur 4 % der Fundstücke auf. In diesem Hort findet sich demnach ein breites Spektrum von Halbfabrikaten über relativ neue bis hin zu sehr abgenutzten Stücken.

Sowohl in Dieskau III als auch in Halle-Kanena III sind bei knapp der Hälfte der Beile mit frischen Scharten zusätzlich Spuren intensiver Nachschärfung zu verzeichnen.

Bei Gröbers-Bennewitz I scheinen die vorliegenden Beschädigungen eher korrosionsbedingt zu sein. Es handelt sich mehrheitlich wohl um relativ neue Beile, die nur zu 7 % nicht überarbeitete Scharten und zu 4 % Spuren intensiver Nachschärfung zeigen. Bei nur zwei mutmaßlichen Halbfabrikaten waren aber fast alle Beile funktionstüchtig.

Demnach ähneln sich Häufigkeit und Art der Gebrauchsspuren innerhalb der einzelnen Fundkomplexe. Auch wenn nur sehr wenige Hortfunde verglichen werden konnten, spricht dies dafür, dass die Beile – sofern benutzt – zuletzt auf ähnliche Weise gebraucht worden sind. Dabei deutet sich ein gemeinsamer letzter Einsatz an, sei es zum Bäume fällen, einer anderen Arbeit oder zum Kampf. Die Art der Nutzung wird in Zukunft experimentell untersucht. Gleichwohl ist der Abnutzungsgrad ungleich. Die Beile unterscheiden sich also im Alter bzw. in der Nutzungsintensität. Auf jeden Fall zeigt sich, dass die Beile nicht nur zentralisiert hergestellt, sondern auch gemeinsam genutzt wurden.

Aufgrund der intensiven Nachschärfung zahlreicher Beile ist eine Funktion als Werkzeug möglich (Billig 1957, 310; Kienlin 2006, 470 f.; Schwarz 2014, 729). Gleichzeitig können die Beile wohl als die üblichen Waffen der Kämpfer im Dienst der Aunjetitzer Fürsten interpretiert werden[26].

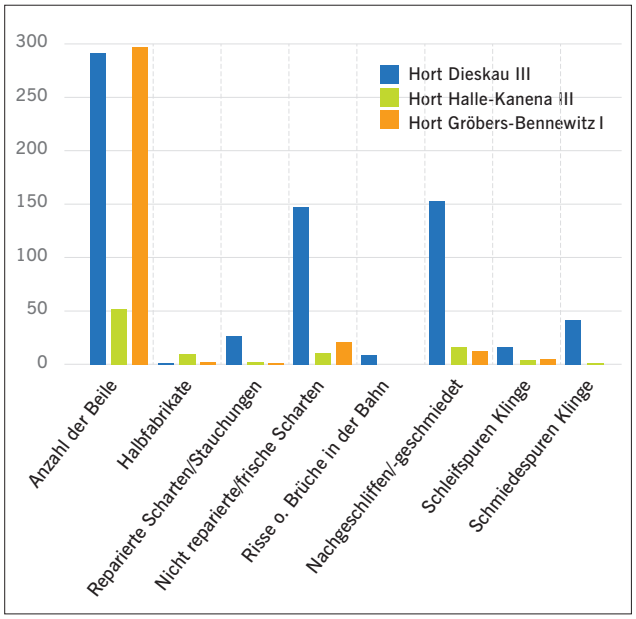


Abb. 25 Häufigkeit unterschiedlicher Gebrauchsspuren an den Beilen aus den Hortfunden Dieskau III, Halle-Kanena III und Gröbers-Bennewitz I.

Fig. 25 *Frequency of various signs of use on the axes of the hoards from Dieskau III, Halle-Kanena III, and Gröbers-Bennewitz I.*

4. Gerippte »Doppeläxte« vom Typ Dieskau

4.1 Forschungsgeschichte

Weniger Beachtung als die zahlreichen Beile fanden die gerippten »Doppeläxte« vom Typ Dieskau[27]. Trotzdem wurden sie in verschiedenen Arbeiten erwähnt, wobei es unterschiedliche Interpretationen hinsichtlich ihrer Herleitung und Beziehungen zu anderen metallenen und auch steinernen

Äxten gibt. Sie wurden als prämonetäre Wertmaßstäbe, Waffen, Würdezeichen oder Zeremonialgeräte angesprochen[28]. Jüngst wurden sie nach einer umfangreichen Auswertung der Funde, Kontexte und Herstellungstechnik als Insignien von »Amtsträgern« gedeutet (Bunnefeld 2019, 192 f.).

4.2 Typologie und Maße

Die schmalen und in der Seitenansicht rechteckigen Äxte des Typs Dieskau haben auf der Ober- und Unterseite längsverlaufende Rippen und sind ansonsten glatt (Abb. 27). Zwischen dem Schneiden- und Nackenteil liegt ein rundes oder ovales Schaftloch. Schon G. Kossinna unterschied zwei Umrissformen, die die Unterteilung in eine rautenförmige und eine weidenblattförmige Variante erlauben (Kossinna 1902, 195; Bunnefeld 2019, 185). Diese unterscheiden sich auch im Verhältnis der Breite zur Länge und in ihrer Verbreitung.

Die mitteldeutschen Äxte gehören sämtlich der schlanken rautenförmigen Variante an und sind mindestens 26,9 cm lang, wobei der Durchschnitt bei 35,7 cm liegt[29]. Auf der Ober- und Unterseite finden sich jeweils fünf Rippen, wobei die mittlere Rippe auf manchen Stücken nicht bis zur Spitze verläuft. Die äußeren Rippen an den Kanten stehen auch in der Seitenansicht hervor und bilden hier somit jeweils zwei Rippen. Ausnahmen bilden jeweils ein Fundstück aus den Horten Dieskau II (Bunnefeld 2019, 194 Nr. 1) und Teicha I (»Doppelaxt« 5) mit drei Rippen (Bunnefeld/Meller in Vorb.) sowie ein Fund aus Serock, Woj. Kujawsko-Pomorskie (Polen), mit nur drei bzw. vier Rippen. Die Hauptverbreitung der rautenförmigen Variante liegt im südlichen Sachsen-Anhalt, Nordthüringen und Westsachsen, dem Kerngebiet der mitteldeutschen Aunjetitzer Kultur (s. Abb. 1).

Die etwas kürzere und breitere weidenblattförmige Variante hat auf der Ober- und Unterseite drei oder fünf Rippen. Diese Fundstücke sind im östlichen Brandenburg, Schlesien, Westpommern und Pommern in Polen und eines sogar in Südschweden geborgen worden (Bunnefeld 2019, 185 f.). Kürzlich wurde ein bemerkenswert langer und schlanker Neufund dieser Variante bekannt, der im September 2015 in der Nähe von sieben frühbronzezeitlichen Ringen in Kamień Pomorski, Woj. Zachodniopomorskie (Polen), am östlichen Mündungsarm der Oder gefunden worden ist (Nowak u. a. 2023, 202–204).

4.3 Fundkontexte und Datierung

Die »Doppeläxte« kommen in Mitteldeutschland ausschließlich in Hortfunden der klassischen Aunjetitzer Kultur (AK 3) oder als Einzelfunde vor, deren Fundumstände letztlich nicht genau bekannt sind (Bunnefeld 2019). In der unmittelbaren Umgebung des neu gefundenen Hortfundes Teicha I, Saalekreis, der unter anderem sechs »Doppeläxte« enthielt, wurden mehrere gleichzeitige Siedlungsgruben entdeckt. Eine ^{14}C-Datierung an Ahornholzresten aus den Schaftlöchern der »Doppeläxte« 1–3 aus diesem Fund ergab ein Datum von 3568 ± 18 BP (MAMS 62947), kalibriert 1939–1890 cal BC (1 σ) bzw. 2013–1826 cal BC (2 σ) und bestätigt somit die typochronologische Einordnung (Bunnefeld/Meller in Vorb.).

4.4 Herstellungstechnik

Die Äxte des Typs Dieskau wurden im Guss hergestellt. Eine Reihe von Fundstücken wurde nicht massiv, sondern hohl über zwei keilförmigen Tonkernen gegossen, die mit dünnen Kernhaltern in der Gießform fixiert waren (Drescher 1958, 34 f.; Bunnefeld 2019, 186–188; Bunnefeld/Meller in Vorb.) (Abb. 28). An einigen Funden sind Gussfehler festzustellen, die nachträglich mittels eines Überfanggusses repariert wurden. Stellenweise sind auch Polierspuren von der Nachbearbeitung im Anschluss an den Guss erhalten geblieben. Die Rippen mancher »Doppeläxte« wurden mit nach dem Guss eingepunzten Kerben verziert.

Ein Vergleich mit den Metallanalysen zur Frühbronzezeit in Mitteldeutschland zeigt, dass die Äxte hinsichtlich der Spurenelemente prinzipiell ihren jeweiligen Beifunden entsprechen[30]. Zehn »Doppeläxte« weisen einen Zinngehalt von mehr als 3 % auf und sind somit aus Zinnbronze hergestellt. Auffällig ist, dass viele Fundstücke aus ungewöhnlichen Legierungen mit hohen Gehalten von Antimon, Nickel und Arsen bestehen, die gerade in poliertem Zustand eine silbrig-glänzende Farbe ergeben können[31]. Wenngleich die Anteile dieser Elemente nicht in jedem Fall eine eindeutig silbrige Färbung hervorriefen, wurden diese Legierungen sicherlich nicht zufällig für die »Doppeläxte« ausgewählt. Angesichts der hohen Sprödigkeit dieser Legierungen ist die offenbar von anderen Funden wie Beilen, Dolchen und Stabdolchen abweichende Farbigkeit ein naheliegender Grund (vgl. Meller 2019b; Wunderlich u. a. 2019).

4.5 Gebrauchsspuren und Funktion

Antike Gebrauchsspuren finden sich an den untersuchten Fundstücken nicht (Bunnefeld 2019; Bunnefeld/Meller in Vorb.). Auffällig sind die Schaftlöcher von ca. 1,5–2,0 cm Durchmesser, die bei einer Funktion als Werkzeug oder Waffe zu schmal für eine dauerhaft stabile Schäftung der meist etwa 450–900 g schweren Axtköpfe erscheinen. Bei drei Stücken aus dem Hort Teicha I waren im Schaftloch Holzreste aus (cf. Feld-)Ahorn (*Acer* cf. *campestre*[32]) erhal-

26 Siehe z. B. Meller 2013, 519; Schwarz 2014, 726; Meller 2015; Meller 2017; Schwarz 2019.

27 Es handelt sich nicht um Doppeläxte im eigentlichen Sinn, da die beiden durch das Schaftloch getrennten Teile unterschiedlich lang sind (Bunnefeld 2019, 183).

28 Siehe z. B. Klemm 1858, 110; Childe 1929, 243; Maraszek u. a. 2011, 108–111. Für eine Zusammenfassung der Forschungsgeschichte siehe Bunnefeld 2019, 183–185.

29 Einschließlich der fünf vollständigen »Doppeläxte« aus dem 2020 entdeckten Hortfund Teicha I, Saalekreis (Bunnefeld/Meller in Vorb.).

30 Die Analyseergebnisse der Hortfunde Dieskau II, Dieskau III und Halle-Kanena II entstammen dem Modul NW2 der Forschergruppe FOR 550 (2004–2010) und sind bislang unpubliziert (s. Beitrag Berger u. a. im vorliegenden Band).

31 Bunnefeld 2019, 187; Wunderlich u. a. 2019; Bunnefeld/Meller in Vorb.; vgl. auch Nowak u. a. 2023, 209 Tab. 2.

32 Für die Holzartenbestimmung möchten wir M. Hellmund, LDA Halle, herzlich danken.

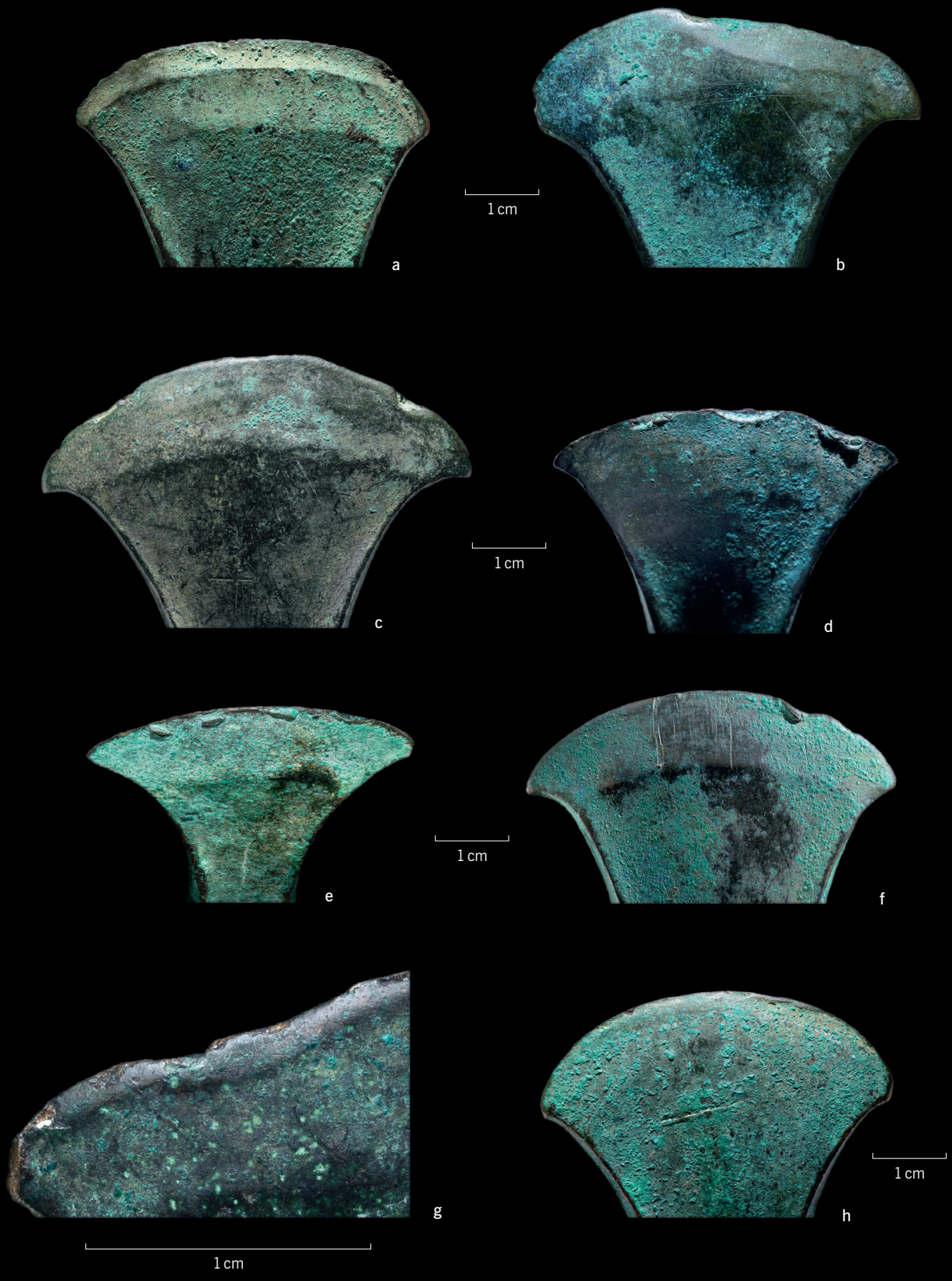
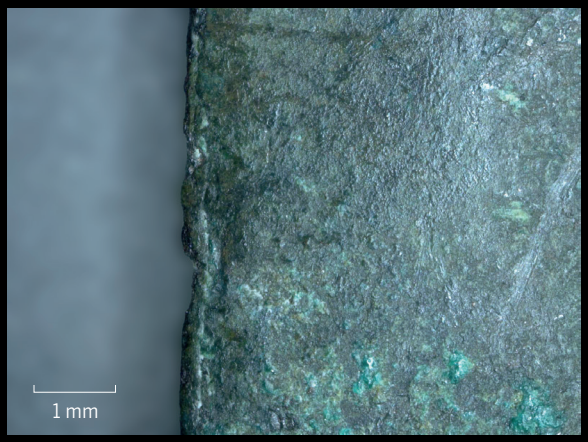


Abb. 26a–p Gebrauchsspuren an den Beilen aus dem Hort Dieskau III. a Asymmetrisch geschliffen, zwei Schneidenfacetten; b ausgebrochen und nachgeschmiedet; c ausgezipfelt, Hammer- und Schleifspuren an der Klinge; d–e starke Scharten; f starke Scharten, senkrechte Kratzer auf der Klinge; g mehrere verschliffene Scharten; h Riss in der Klinge; i leichte Stauchung; j–l leichte Scharte; m–n Scharte; o Scharte (Aufsicht); p überschliffene Scharte.

Fig. 26a–p *Use-wear on the axes from the hoard of Hort Dieskau III. a Asymmetrically ground, two facets on the cutting edge; b partially broken off cutting edge, reforged; c elongated blade tips, traces of hammering and grinding; d–e heavy nicks; f heavy nicks, vertical scratches on the blade; g several ground out nicks; h crack in the blade; i slight buckling; j–l small nick; m–n nick; o nick (top view); p ground out nick.*



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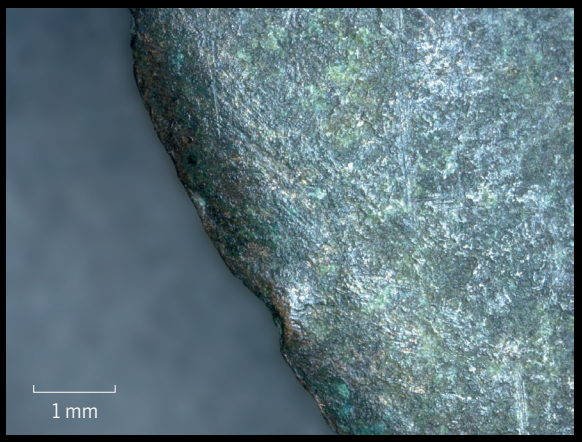

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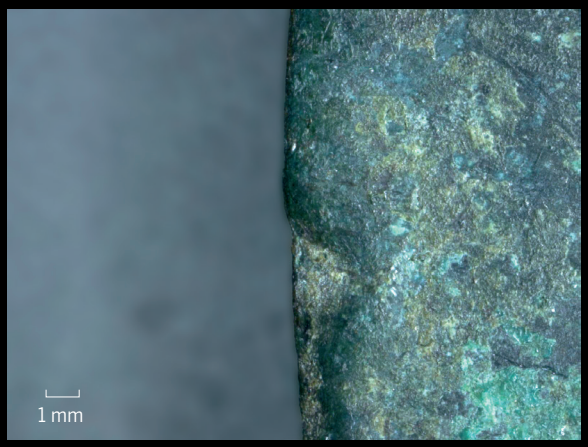

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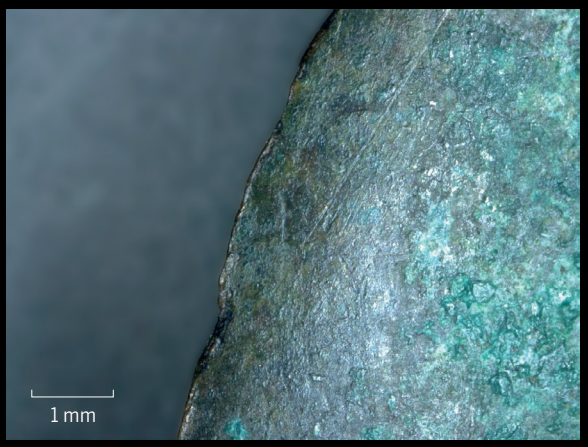

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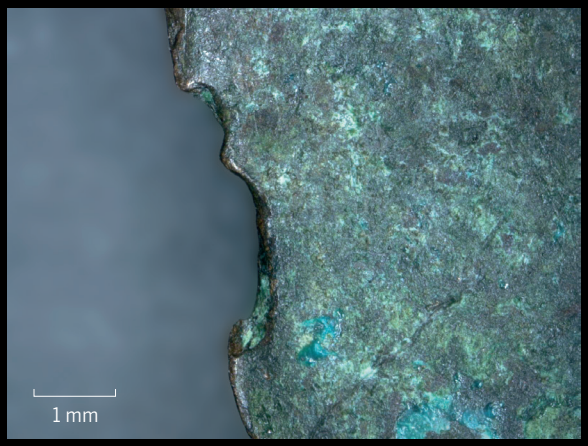

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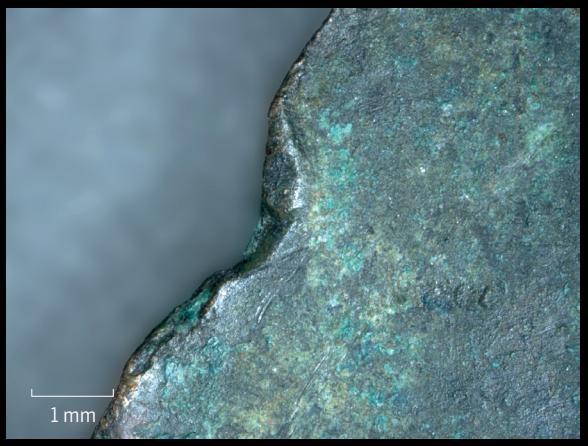

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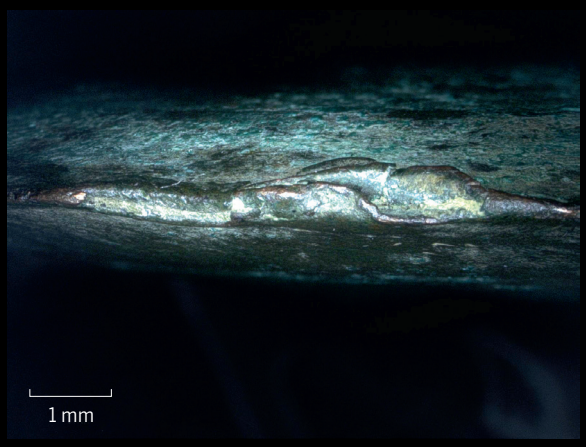

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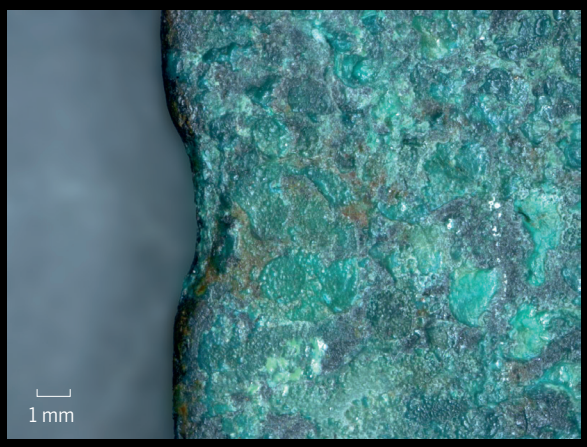

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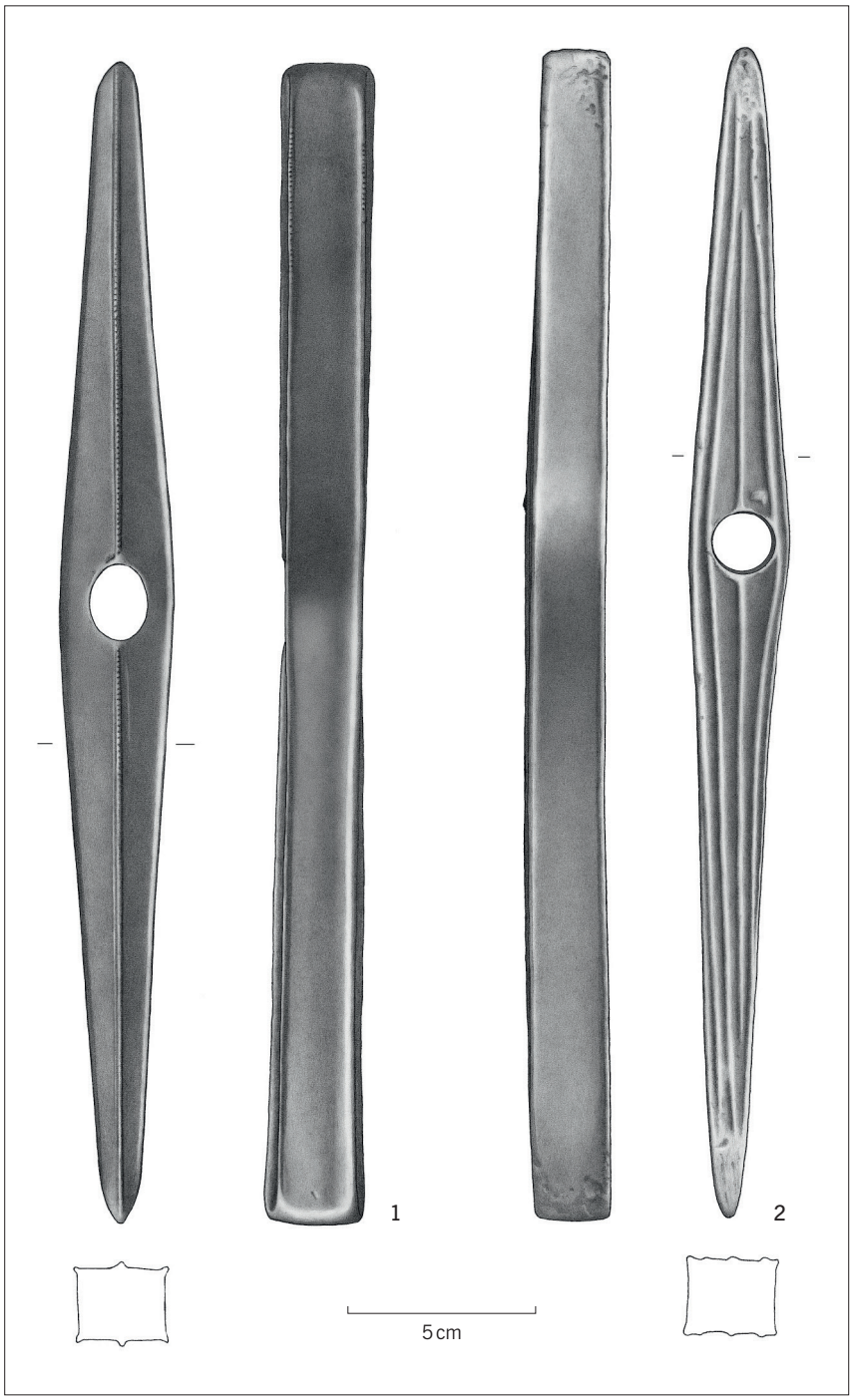

Abb. 27 Die beiden gerippten »Doppeläxte» vom Typ Dieskau aus dem Hort Dieskau II.

Fig. 27 *The two ribbed »double axes« of the Dieskau type from the Dieskau II hoard.*

ten. Ahorn ist ein festes, elastisches Holz, das auch heute noch für Werkzeugstiele verwendet wird (Grosser/Ehmcke 2015). Darin steckte jeweils ein Nietstift, wobei der zugehörige Nietkopf auf dem Schaftloch auflag (Abb. 29). Zum einen könnten die Nietstifte zur Stabilisierung der Schäftung gedient haben. Zum anderen demonstriert die Abdeckung der Schaftlöcher durch die Nietköpfe aber, dass auch ästhetische Gesichtspunkte zu berücksichtigen sind. Zum Vergleich wiegen die meisten schnurkeramischen Facettenäxte in Mitteldeutschland 250–500 g[33] und haben ca. 1,5–2,5 cm durchmessende runde Schaftlöcher. Die bronzenen Nackenscheibenäxte in Österreich haben mit 200–350 g ein deutlich geringeres Gewicht als die gerippten Äxte, aber dennoch durchschnittlich ein wenig größere Schaftlöcher von 1,8–2,0 cm Durchmesser (Mayer 1977, 39–41). Neben den wohl zu kleinen Schaftlöchern spricht gegen eine praktische Verwendung der gerippten Äxte vom Typ Dieskau, dass mehrere Fundstücke hohl über Tonkernen gegossen wurden und ihre Stabilität deshalb für einen intensiveren Gebrauch als Schlaggerät oder -waffe nicht ausgereicht hätte. Nicht

33 Für die freundliche Mitteilung danken wir S. Meinecke, UAB Barcelona.

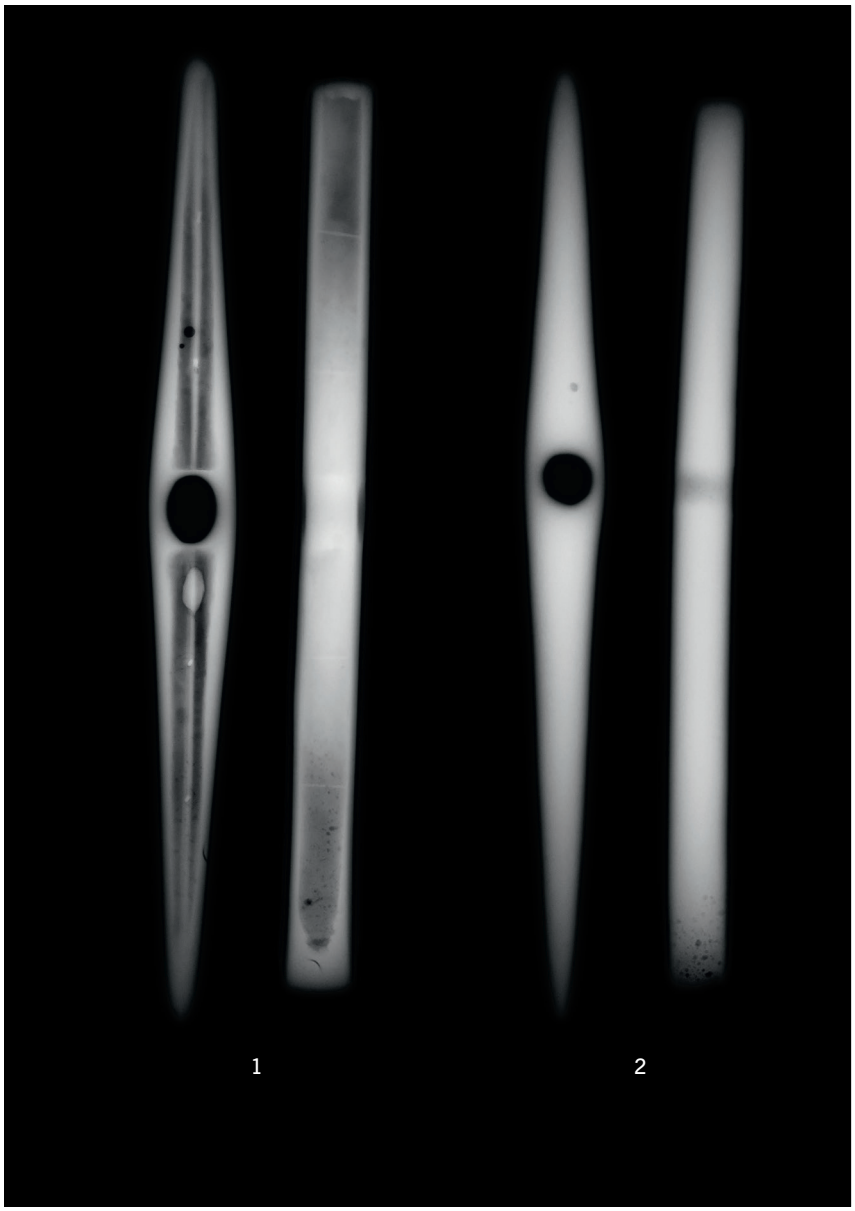

Abb. 28 Röntgenbilder der zwei gerippten »Doppeläxte» aus dem Hort Dieskau II. Die Stücke sind zum Teil hohl über Tonkernen gegossen worden, die mit Kernhaltern fixiert wurden. Bei der hohl gegossenen Axt (1) sind diese sowie ein Überfangguss erkennbar.

Fig. 28 *X-ray images of the two ribbed »double axes« from the Dieskau II hoard. They were partially cast hollow over clay cores. The hollow-cast axe (1) shows the core supports and that the casting was not done in one go, but additional pieces were cast on to it.*

zuletzt sind die häufig spröden Legierungen für eine praktische Funktion und mechanische Belastungen ungünstig (Wunderlich u. a. 2019).

Bei den »Doppeläxten« handelt es sich um vergleichsweise aufwendige Produkte, die recht viel Material benötigten. Eine Funktion als prämonetäre Wertmaßstäbe, wie von V. G. Childe vorgeschlagen (Childe 1929, 243), ist angesichts der völlig individuellen Gewichte auszuschließen. Wie die Niete in den Holzschäften von Teicha I und Überfanggüsse zur Reparatur von Gussfehlern demonstrieren, war ein möglichst fehlerfreies ästhetisches Erscheinungsbild gewünscht. In der Form ähneln die Axtköpfe einigen lanzettförmigen Steinäxten, von denen sie wohl auch herzuleiten sind (Abb. 30). Dabei wurden aber die Möglichkeiten des neuen metallischen Werkstoffs genutzt, um die Stücke durch eine ungleich schlankere und feingliedrigere Form und eine besondere Farbigkeit von den steinernen Vorbildern abzusetzen (Bunnefeld 2019, 191 f.).

Im Vergleich zu vielen anderen Fundgruppen in der Aunjetitzer Kultur sind die Äxte des Typs Dieskau mit insgesamt höchstens 25 bekannten Exemplaren sehr selten. Im mitteldeutschen Raum treten sie gesichert ausschließlich in Hortfunden auf, weshalb sie nicht als direkte Attribute der Fürsten gelten können, wie sie in den bekannten Großgrabhügeln von Leubingen, Helmsdorf und dem Bornhöck repräsentiert sind[34]. In den Fürstengräbern sind nämlich sonst durchaus Objekte – beispielsweise Beile, Stabdolche, Dolche sowie früh- und mittelneolithische Steinäxte – beigegeben worden, die normalerweise nicht in Grabkontexten der Aunjetitzer Kultur vorkommen (Meller 2019c). Aus demselben Grund handelt es sich vermutlich auch nicht einfach um ein weiteres Attribut der militärischen Hierarchie, die in den Fürstengräbern z. T. in vollem Umfang repräsentiert ist[35]. Dennoch hatten die »Doppeläxte« offensichtlich angesichts ihres seltenen, aber fast regelhaften Vorkommens in mittel-

34 Vgl. z. B. Meller 2019; Meller 2019a; Meller 2019c.

35 Meller 2015; Meller 2017; Meller 2019b; Meller 2019c.

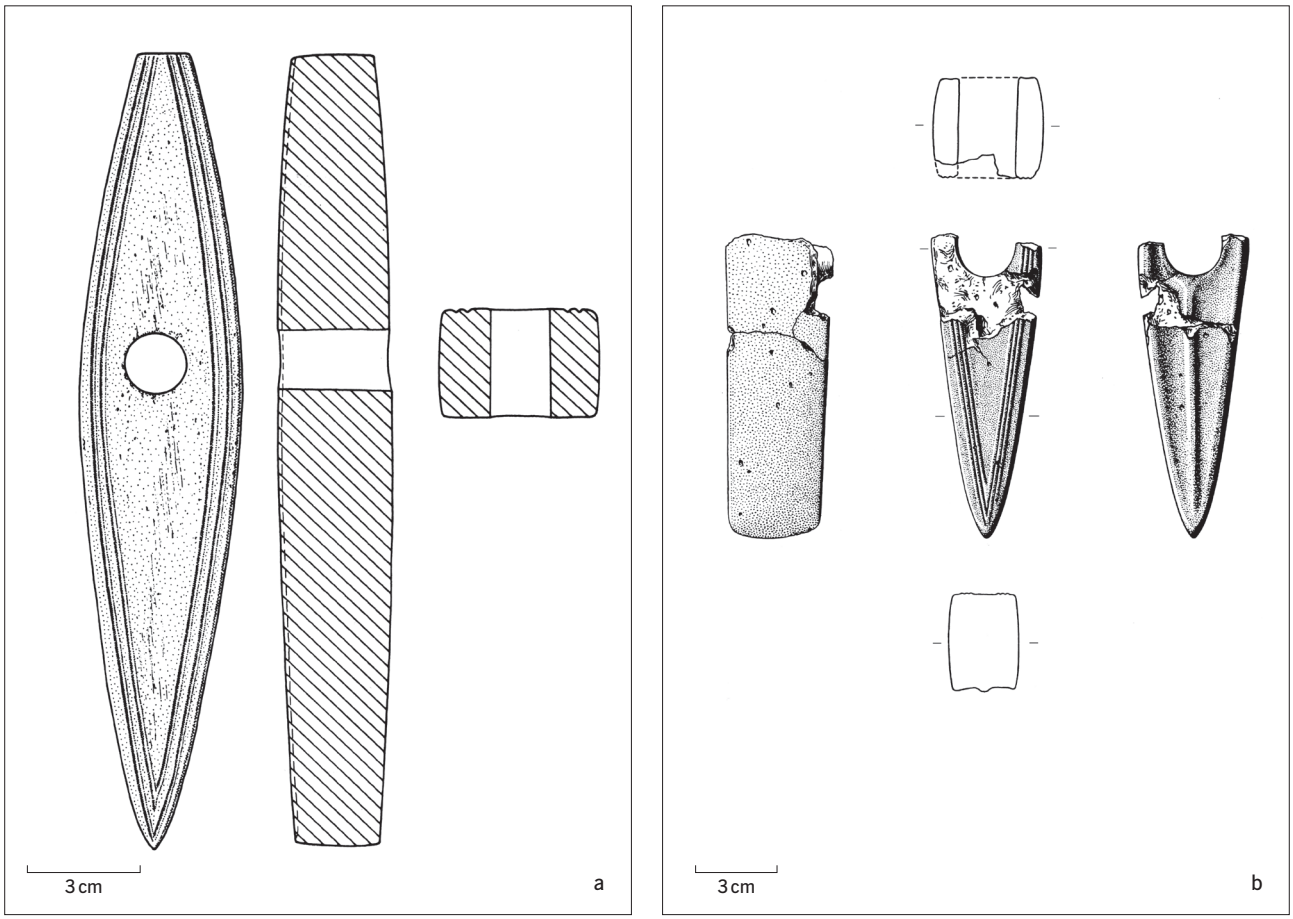

Abb. 30a–b Die »Doppeläxte» sind wahrscheinlich als Nachfolger steinerner lanzettförmiger (Doppel-)Äxte anzusehen, ähnlich denen aus (a) Franzhausen I (Grab 840), Bez. Sankt Pölten-Land (Österreich), und (b) aus der Lüneburger Heide (Niedersachsen), wobei die Stücke aus Bronze durch eine ungleich schlankere und feingliedrigere Form und eine besondere Farbigkeit von den steinernen Vorbildern abgesetzt wurden.

Fig. 30a–b *The »double axes« probably need to be regarded as the successors of lancet-shaped (double) axes of stone, similar to the ones from (a) Franzhausen I (grave 840), Sankt Pölten-Land district (Austria), and (b) the Lüneburg Heath (Lower Saxony), even though the bronze exemplars contrast with their stone models by their much more slender and delicate shape and a particular metal colour.*

deutschen Horten – stets in Verbindung mit Waffen – eine spezifische Bedeutung in der Aunjetitzer Kultur, vor allem der Circumharzer Gruppe. Möglicherweise handelt es sich um eine weitere Hierarchiestufe bzw. die Insignien einer speziellen Personengruppe, z. B. »Amtsträgern«.

Auf eine besondere Rolle deutet das Material hin, das im Gegensatz zu Beilen, Stabdolchen und Dolchen unterschiedliche Legierungen umfasst, die im Allgemeinen gut polierbar waren und einen silbrig-grauen Glanz ermöglichten, der vielleicht durch die Rippen zusätzlich hervorgehoben wurde (Wunderlich u. a. 2019). Möglicherweise standen die gerippten Äxte auch in einer bewussten Traditionslinie zu ihren steinernen Vorgängerformen. In den Fürstengräbern von Leubingen und Helmsdorf sind wahrscheinlich der Legitimation dienende Traditionsbezüge festzustellen, u. a. die Beigabe viel älterer neolithischer Steinäxte (s. u.). Es könnte deshalb sein, dass auch die »Doppeläxte« Bezug auf ältere Steinäxte nehmen und damit verbundene Bedeutungen transportierten.

Abb. 29 (linke Seite) In den Schaftlöchern von drei »Doppeläxten» aus dem Hort Teicha I waren Ahornreste erhalten, in denen jeweils ein Niet steckte, dessen Kopf den Schaft abdeckte.

Fig. 29 (left page) *Maple wood remains were preserved in the shaft holes of three »double axes« from the Teicha I hoard. In each of them, a rivet was inserted, whose head covered the shaft hole.*

5. Sonstige Beile und Äxte

Neben den Sächsischen Randleistenbeilen und den gerippten »Doppeläxten« sind aus der Aunjetitzer Kultur Mitteldeutschlands vereinzelt auch andere Beil- und Axtformen bekannt. In manchen Fällen handelt es sich um andere, teils fremde Formen von Randleistenbeilen, in weiteren Fällen um in Mitteldeutschland einzigartige Stücke und alte Steinäxte, die in herausgehobenen Bestattungen auftreten.

5.1 Andere Randleistenbeile

An dieser Stelle sollen kurz weitere Formen von Randleistenbeilen angesprochen werden, die in Hortfunden und Gräbern vorkommen. Bemerkenswert ist besonders der Hortfund von Dermsdorf mit einem vergleichsweise heterogenen Inventar von Beilen (Abb. 31). Hier liegen typochronolo-

gisch ältere Formen (kleine Sächsische Randleistenbeile, sog. Typ Salez) zusammen mit jüngeren zinnhaltigen Stücken vor (große, zinnhaltige Sächsische Randleistenbeile, »langgestielte Beile«, Typ Neyruz). Anzunehmen ist ein zeitversetztes Auftreten der unterschiedlichen Beilformen und ihre partiell gleichzeitige Produktion (Küßner/Wechler 2019, 449–457).

Die in der Stufe Bz A2c in Kläden, Lkr. Stendal, zusammen mit einem langen Meißel, einer Hülsenkopfnadel und einer verschollenen Lanzenspitze deponierten elf Beile (zwei langgestielte Beile vom Typ Kläden, drei Löffelbeile u. a. der Typen Rümlang und Bevaix, zwei Beile vom Typ Langquaid II bzw. nah verwandt, ein Fragment mit sich geradlinig zur Schneide verbreiternder Bahn, drei Sächsische Randleistenbeile) sollen hier nur knapp erwähnt werden, da sie aus der nördlich der Aunjetitzer Kultur gelegenen Altmark stammen. Sie sind zum Teil aus dem westlichen Alpenraum importiert bzw. beeinflusst[36]. Außerdem ist mit dem Löffelbeil aus Bergfarnstädt, Saalekreis, auch in der Circumharzer Gruppe ein importiertes oder nachgeahmtes westalpines Stück bekannt (Schwarz 2023a).

Auch in Grabkontexten kommen andere Beilformen vor (Abb. 32). Im Flachgrab von Osmünde, Saalekreis (AK 3b), war neben zwei goldenen Noppenringen ein zinnbronzenes Beil vom schweizerischen und südwestdeutschen Typ Neyruz enthalten (Meller 2014, 696 f. Nr. 16; Schwarz 2021, 105 f.). Das Randleistenbeil aus Nobitz, Lkr. Altenburger Land, das anscheinend ohne geschlossenen Fundzusammenhang in einem schnurkeramischen Grabhügel gefunden wurde (Behrens 1971, 145 Abb. 7; Zich 1996, 217; 509 Nr. H5), weist mit seiner halbkreisförmigen Schneide ein jüngeres Merkmal auf (AK 4a/Bz A2b; Schwarz 2021, 208). In Naundorf (AK 4) wurde ein frühes Böhmisches Absatzbeil aus Zinnbronze in Grab 4 gefunden (Billig 1958, 43 f.; Zich 1996, 534 Nr. K163)[37]. Schmale Randleistenbeile sind aus den späten Gräbern (AK 5) von Schkeuditz-Wehlitz, Lkr. Nordsachsen (Rummer u. a. 2018), und Hohenbergen (auch unter Österkörner bekannt), Unstrut-Hainich-Kreis (u. a. Fröhlich 1983, 24 f.; 198 Taf. 63, A1–3.5; Zich 2016, 393 Nr. 28), bekannt. Bemerkenswerterweise war das Beil von Hohenbergen laut P. Höfer, der sich auf einen sorgfältigen Grabungsbericht bezieht, nicht in einem Knieholm geschäftet, sondern der Schaft habe sich »der Länge nach« fortgesetzt (Höfer 1906, 36). Ob sich hier eine besondere Form der Schäftung zeigt, wie sie auch in Periode II bei dem reich verzierten Beil aus Gunderup, Nordjütland (Dänemark), belegt ist und vielleicht für eine Art Würdezeichen oder Standarte sprechen könnte, bleibt offen (Sprockhoff 1941, 110 f.; Billig 1957, 311 f.).

Abb. 31 (linke Seite) In Dermsdorf, Lkr. Sömmerda, wurden an der Schmalseite eines großen dreischiffigen Hauses 98 Beile und zwei Rohlinge für Stabdolchklingen in einem Tongefäß deponiert.

Fig. 31 (left page) *In Dermsdorf, Sömmerda district, 98 axes and two halberd blanks had been deposited in a clay vessel at the narrow side of a big three-naved house.*

5.2 »Anglo-irische« Beile

Verzierte »anglo-irische« Flach- und Randleistenbeile sind von Irland bis Südskandinavien und von Frankreich und den Niederlanden bis Mitteldeutschland verbreitet (u. a. Jockenhövel 2004; O'Connor 2010) (Abb. 33). Aus der klassischen und nachklassischen Aunjetitzer Kultur in Mitteldeutschland sind fünf Fundstücke zu nennen, davon zwei Importe und drei Nachahmungen (Billig 1957, 300–304; Maraszek 2023) (Abb. 34). Aus dem Hortfund Dieskau II ist ein 12,8 cm langes trapezoides Beil mit »Regentropfenmuster« bekannt, das nach neuen Analysen 9,9 % Zinn enthält und keine erkennbaren Gebrauchsspuren zeigt (von Brunn 1959, 56; Taf. 16,3). Typologisch wird es dem mittelenglischen Typ Falkland zugeordnet, der nah mit dem weitgefassten irischen Typ Ballyvalley verwandt ist. Auf beiden findet sich häufig auch die »Regentropfenverzierung« (Harbison 1969, 32–55; 67–69; Schmidt/Burgess 1981, 62 f.). Eine sehr enge Parallele findet sich außerdem im südwestenglischen Dorset (O'Connor 2010, 597 f.).

Aus Weßmar, Saalekreis, stammt ein noch 13,8 cm langes Beil, dessen hintere Bahn und Nacken fehlen. Die Verzierung beider Seiten ist unterschiedlich, wird aber von kreuz-, schräg- und waagerecht schraffierten Dreiecken und Tannenzweigmustern gebildet (Billig 1957, 288–290). Es enthält nach neuen Röntgenfluoreszenzanalysen 10,3% Zinn und kann wahrscheinlich dem irischen Typ Derryniggin zugewiesen werden, der zudem oft ähnlich angeordnete Ornamente trägt. Ein irisches Beil von unbekanntem Fundort hat eine sehr ähnliche Verzierung wie Weßmar (Harbison 1969, 55–64; bes. 59 Nr. 1815). Das Beil ist damit wohl in die nachklassische Phase der Aunjetitzer Kultur (AK 4) zu datieren, wobei jedoch die Datierung der Beile auf den Britischen Inseln im Detail mit Unsicherheiten behaftet bleibt (vgl. Jockenhövel 2004, 158; Roberts u. a. 2013). Die Fundstelle befindet sich nahe des Bornhöck und der reichen Hortfunde von Dieskau.

Das mit 23,5 cm Länge besonders große Beil mit parallelen Seiten aus Schweta, Lkr. Nordsachsen, wurde wohl zusammen mit zwei schweren ovalen offenen Ringen deponiert. Es ist in fünf Zonen mit hängenden Winkeln, einer Reihe gekreuzter Schrägstriche, stehenden wechselseitig schraffierten Dreiecken und zweimal jeweils einer Reihe gekreuzter Schrägstriche sowie hängender wechselseitig schraffierter Dreiecke verziert. Das Beil enthält 7,4 % Zinn[38] und ist unbenutzt (Billig 1957, 288; Billig 1958, 118–120; von Brunn 1959, 67). Die Form des Beils fällt noch in die Variationsbreite der Sächsischen Randleistenbeile, aber es ähnelt auch den westeuropäischen Beilen der Typen Arreton und Derryniggin. Allerdings findet die Anordnung der Verzierungselemente, anders als bei Dieskau II und Weßmar, hier keine gute Parallele (Harbison 1969, 55–64; Schmidt/Burgess 1981, 72–75; Schwarz 2019). Da die beiden Ringe typische Formen der klassischen Aunjetitzer Kultur darstellen, kann man das Beil vorsichtig in die klassische Phase der Aunjetitzer Kultur (AK 3) setzen (vgl. Schwarz 2021). Bei

36 von Brunn 1959, 61; Abels 1972; Kibbert 1980; Schwarz 2023a; Maraszek 2024.

37 Siehe die erweiterte SAM-Datenbank, FMZM0993 (Krause 2003, CD-Rom).

38 Siehe die erweiterte SAM-Datenbank, FMZM0953 (Krause 2003, CD-Rom).

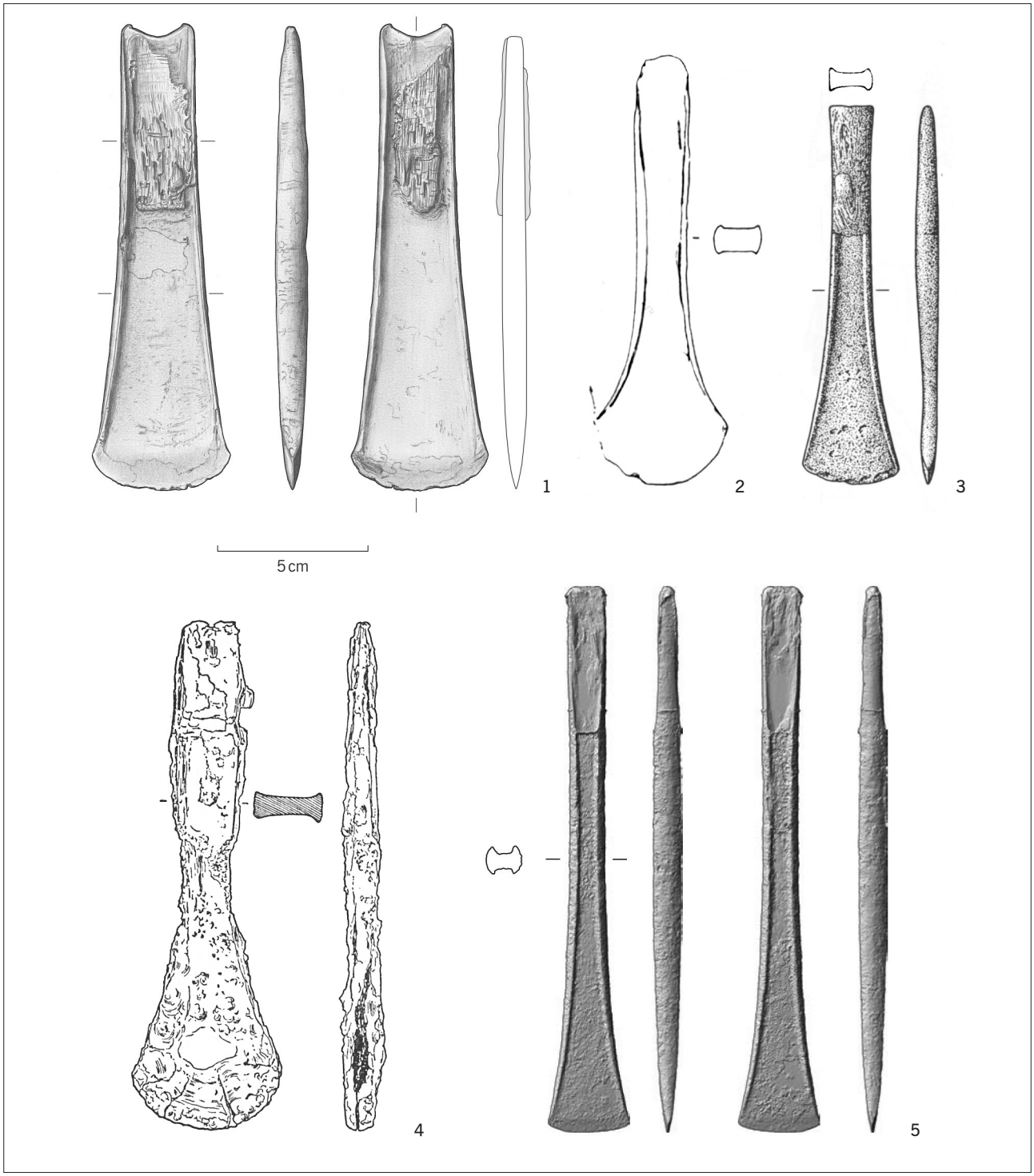

Abb. 32 In wenigen Gräbern kommen Randleistenbeile vor, die nicht dem Sächsischen Typ entsprechen: 1 Osmünde, Saalekreis; 2 Nobitz, Lkr. Altenburger Land; 3 Hohenbergen (= Österkörner), Unstrut-Hainich-Kreis; 4 Naundorf, Lkr. Meißen (Grab 4); 5 Schkeuditz-Wehlitz, Lkr. Nordsachsen.

Fig. 32 *Few graves contain flanged axes that do not belong to the Saxonian type: 1 Osmünde, Saalekreis district; 2 Nobitz, Altenburger Land district; 3 Hohenbergen (= Österkörner), Unstrut-Hainich-Kreis district; 4 Naundorf, Meißen district (grave 4); 5 Schkeuditz-Wehlitz, Nordsachsen district.*

späteren Grabungen wurde erkannt, dass der Hortfund im Bereich einer frühbronzezeitlichen Siedlung niedergelegt worden ist (Conrad u. a. 2014, 125–127).

In Griefstedt, Lkr. Sömmerda, nicht weit entfernt vom Fürstengrab von Leubingen und dem außergewöhnlich großen dreischiffigen Haus mit Hortfund von Dermsdorf, wurden neben zwei Thüringer Ringen, einer Armmanschette und einem schlichten Sächsischen Randleistenbeil zwei 21,3 cm lange, sehr dünne Sächsische Randleistenbeile gefunden, die mit feinen Kerben an den Randleisten, diese begleitenden Punktreihen, doppelten Querreihen von kurzen vertikalen oder leicht schrägen Strichen in der Bahn und unregelmäßigen, gebogenen Punktreihen im Klingenbereich verziert sind (von Brunn 1959, 57). Sie enthalten ca. 6 % Zinn, wurden in derselben zweischaligen Gießform hergestellt und sind unbenutzt (Billig 1957, 290).

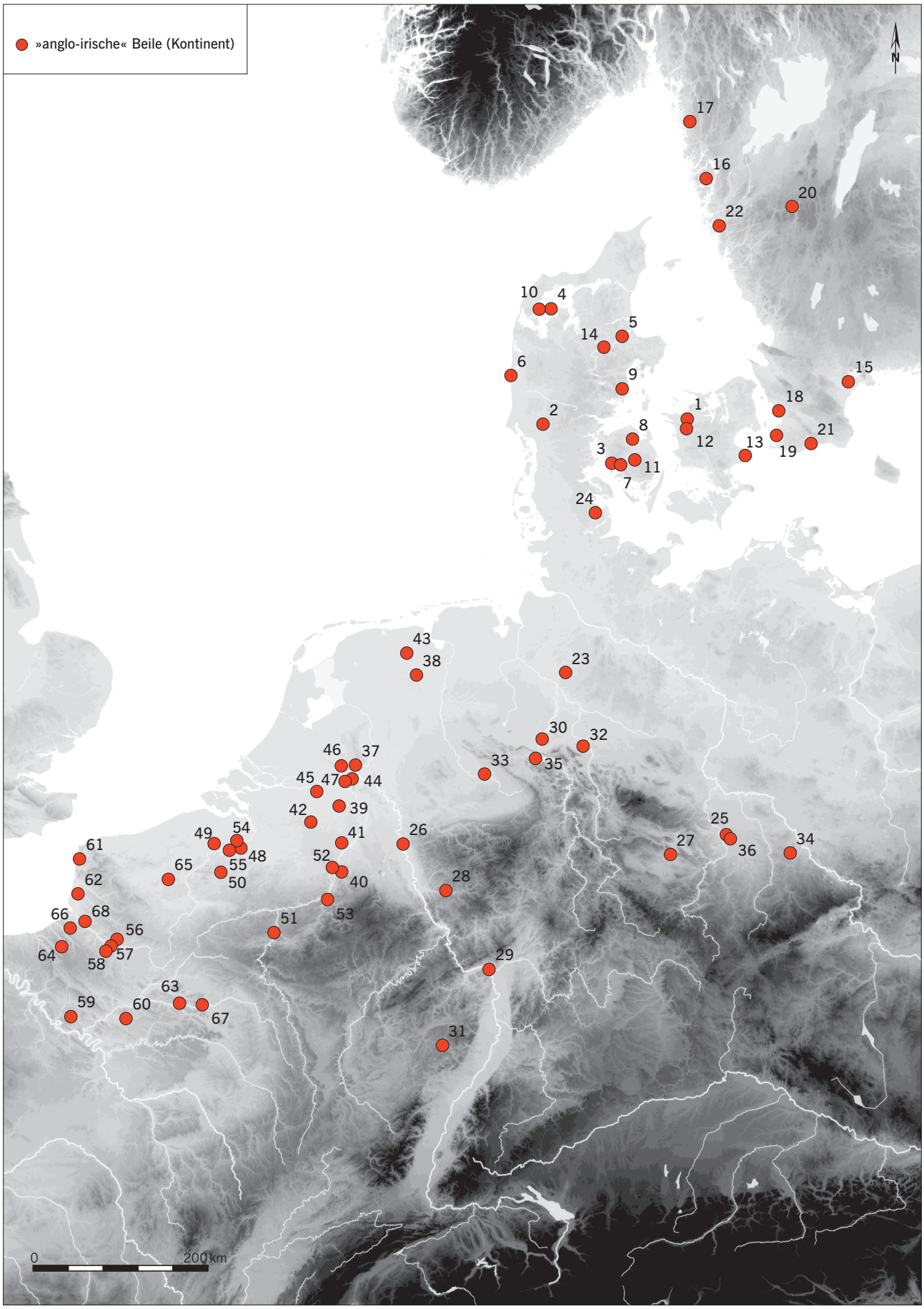

Abb. 33 Verbreitung »anglo-irischer» Beile auf dem europäischen Kontinent (vgl. Liste 4).

Fig. 33 *Distribution map of »Anglo-Irish« axes on the mainland of Europe (see List 4).*

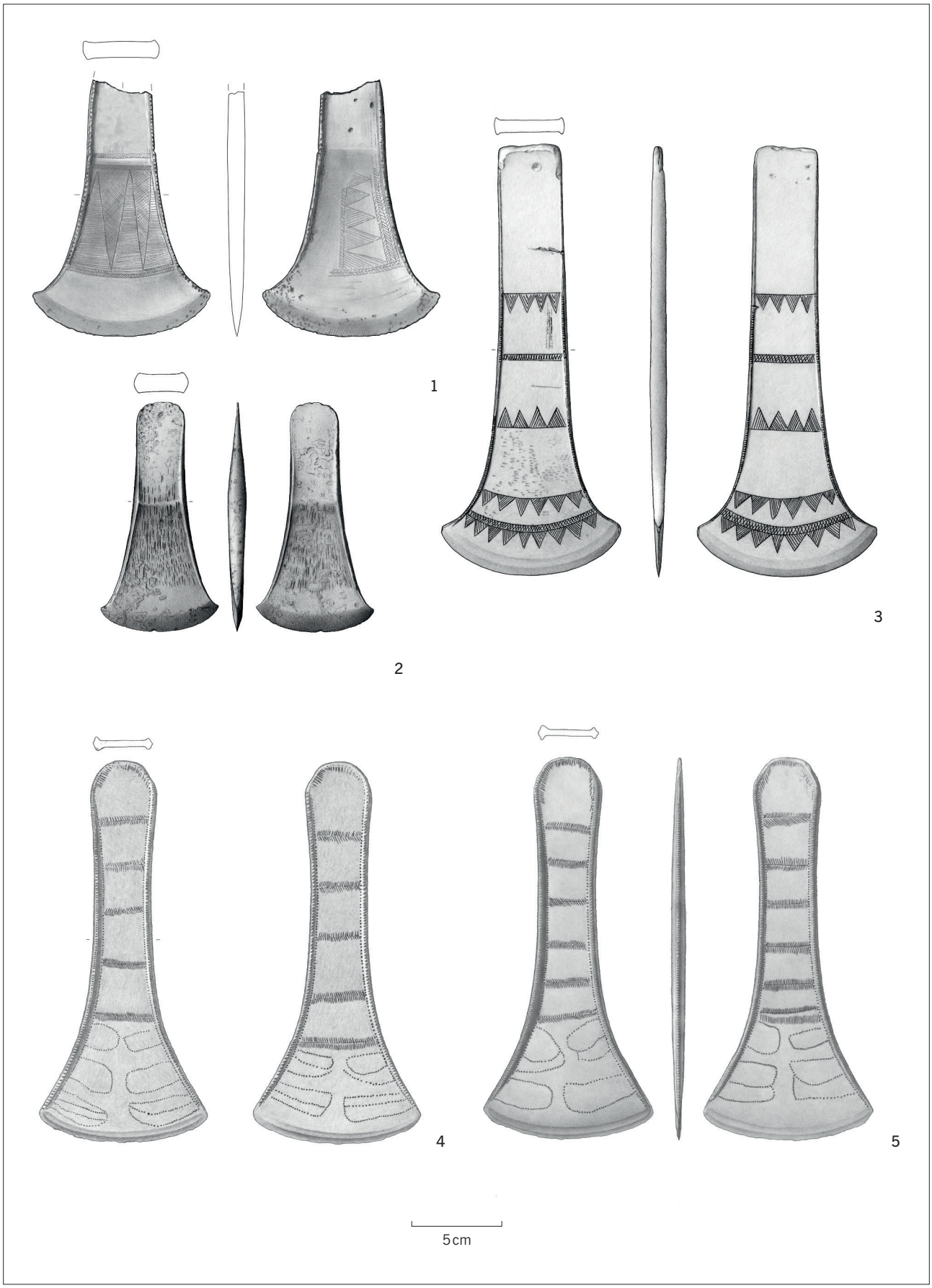

Abb. 34 In Mitteldeutschland sind zwei importierte »anglo-irische« Randleistenbeile (1–2) und drei Imitationen (3–5) bekannt. 1 Weßmar, Saalekreis; 2 Dieskau II, Saalekreis; 3 Schweta, Lkr. Nordsachsen; 4–5 Griefstedt, Lkr. Sömmerda.

Fig. 34 *In Central Germany, two imported »Anglo-Irish« flanged axes (1–2) and three imitations (3–5) are known. 1 Weßmar, Saalekreis district; 2 Dieskau II, Saalekreis district; 3 Schweta, Nordsachsen district; 4–5 Griefstedt, Sömmerda district.*

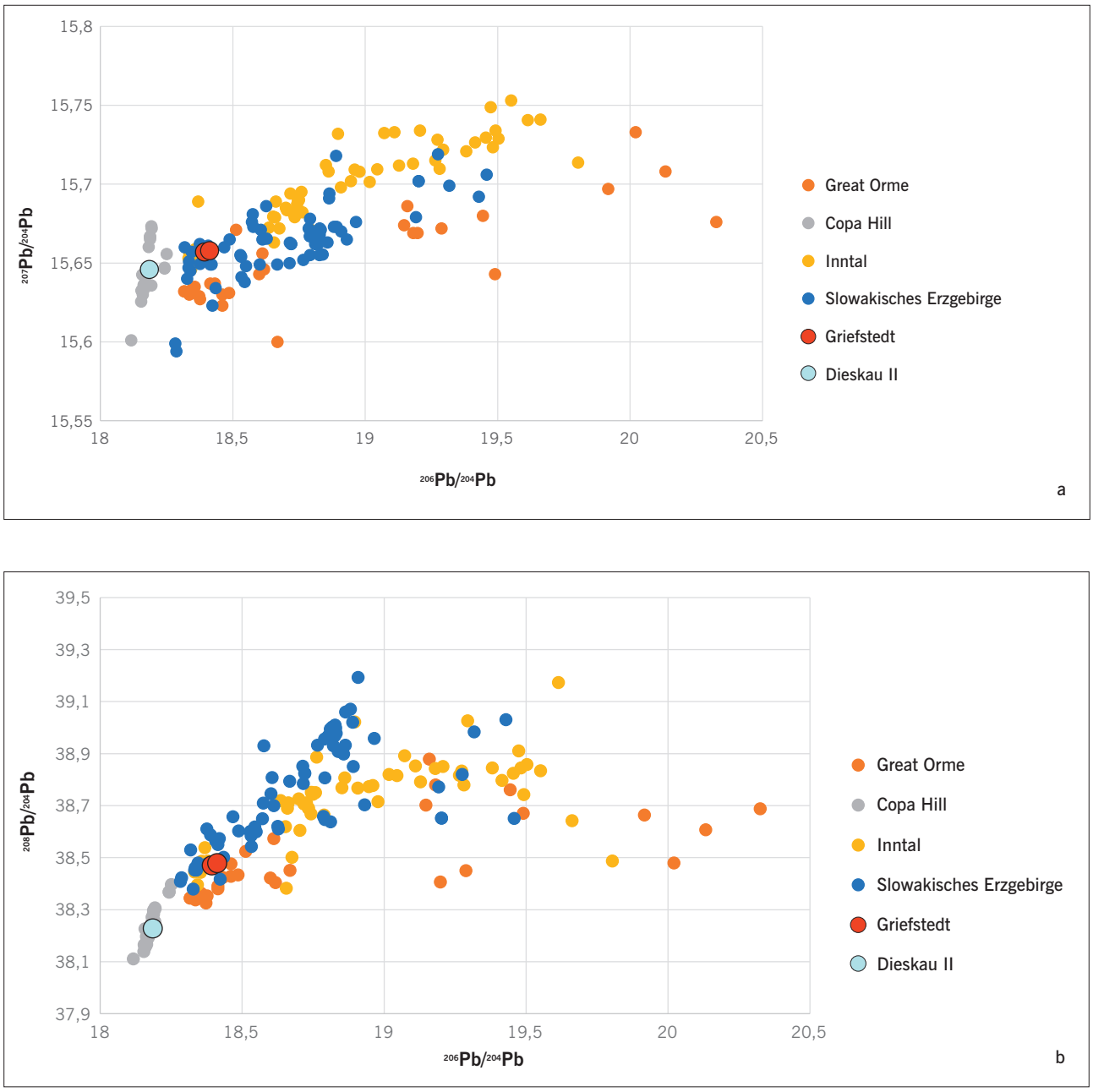

Abb. 35a–b Bleiisotopendiagramme der »anglo-irischen» Beile im Vergleich zu Erzen aus West- und Mitteleuropa. Es zeigt sich, dass das Beil aus Dieskau II aus walisischem Erz besteht, während die beiden Beile aus Griefstedt aus alpinem oder slowakischem Erz hergestellt worden sind.

Fig. 35a–b *Lead isotope diagrams of the »Anglo-Irish« axes compared to the ores from Western and Central Europe. As can be seen, the axe from Dieskau II is made of Welsh ore, whereas the two axes from Griefstedt are made of Alpine or Slovak ore.*

Die Metallanalysen bieten eine weitere Möglichkeit, zwischen Importen und Nachahmungen zu unterscheiden (vgl. Jockenhövel 2004, 165; Berger u. a. in Vorb.)[39]. Das kleine Beil aus Dieskau II besteht aus einem spurenelementarmen Chalkopyrit- oder Malachitkupfer, dessen Bleiisotopenverhältnisse nach Wales, vielleicht auf die Copa Hill Mine, verweisen (vgl. Nørgaard u. a. 2021, 11–13) (Abb. 35; Tab. 8). Das Beil aus Weßmar ist chemisch sehr ähnlich, aber eine Bleiisotopenanalyse liegt nicht vor. Diese beiden Beile mit hohen Zinngehalten stellen demnach wahrscheinlich westeuropäische Importe dar, was durch die Typologie und Verzierung gestützt wird. Hingegen bestehen die Beile aus Schweta und Griefstedt aus Fahlerzkupfer, dem sog. Ösenringkupfer, oder einer Mischung, in der dieses dominiert (s. Beitrag Berger u. a. in diesem Band). Die Bleiisotopenverhältnisse der Griefstedter Beile, die vergrößerte Sächsische Randleistenbeile sind, entsprechen ebenfalls denen des Ösenringkupfers, wobei nicht zu entscheiden ist, ob es aus dem

39 Wir bedanken uns bei D. Berger, CEZA Mannheim, für freundliche Hinweise und seine Unterstützung bei der Auswertung der Metallanalysen.

a							
Proben-nummer	Museum, Inv.-Nr.	Fundort	Fe	Co	Ni	Cu	Zn
RFA 204	LV Halle, HK 7476	Wessmar	0,03	0,05	0,022	89	< 0,2
RFA 146	LV Halle, HK 45:38b	Dieskau II	< 0,02	< 0,01	0,032	90	< 0,2
RFA 178	LV Halle, HK 34:223b	Griefstedt	< 0,02	< 0,01	0,034	90	< 0,2
RFA 206	LV Halle, HK 34:223c	Griefstedt	< 0,02	< 0,01	0,026	90	< 0,2
FMZM0953	Dresden S.828/52	Schweta	< 0,05	< 0,005	0,03	88	< 0,1

b							
Proben-nummer	Museum, Inv.-Nr.	Fundort	$^{208}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$ 2σ	$^{207}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$ 2σ	$^{206}Pb/^{204}Pb$
MA-071733	LV Halle, HK 45:38b	Dieskau II	2,1022	0,0001	0,86039	0,00001	18,185
MA-071765	LV Halle, HK 34:223b	Griefstedt	2,0917	0,0001	0,85127	0,00001	18,393
MA-071813	LV Halle, HK 34:223c	Griefstedt	2,0900	0,0001	0,85043	0,00001	18,412

Inntal oder aus dem Slowakischen Erzgebirge stammt. Bei Schweta und Griefstedt mit ihren geringeren Zinngehalten handelt es sich offenbar um einheimische Nachahmungen »anglo-irischer« Beile. Diese sind im Kontext der offenbar bestehenden Verbindungen zwischen der Aunjetitzer Kultur in Mitteldeutschland und der Wessex-Kultur in Südengland zu sehen, über die auch Gold und wahrscheinlich Zinn nach Mitteleuropa gelangten (vgl. u. a. Gerloff 2010, 617–622; Maraszek 2020; Borg/Meller 2021). Ihre herausragende Größe (abgesehen von Dieskau II), Verzierung und fehlende Gebrauchsspuren sprechen für eine Funktion als Würdezeichen oder Insignien (vgl. Billig 1957).

5.3 Einzelstücke

Wie Beilklingen geschäftet und im Schaft mit Schnur umwickelt waren, zeigt das frühe Tüllenbeil von Kütten-Drobitz, Saalekreis, das zusammen mit einer Stabdolchklinge gefunden wurde (von Brunn 1959, 61 f.) (Abb. 36). Eine im Querschnitt spitzovale gerippte Tülle mit einem Niet geht in eine von Randleisten gesäumte Bahn und Klinge über. Das Stück wurde in zweischaliger Form gegossen (Billig 1957, 294 f.). Es handelt sich um einen sehr frühen Vorläufer der Tüllenbeile, der aber in Mitteleuropa keine unmittelbaren Nachfolger fand (s. Beitrag Dietrich in diesem Band).

Die Nackenkammaxt von Naumburg, Burgenlandkreis, wurde zusammen mit vier Randleistenbeilen, zwei fragmentierten Beilen, dem Griff eines Vollgriffdolchs, einem zungenförmigen Rohling von plankonvexem Querschnitt, einer gerippten Manschette und einem Bruchstück einer solchen sowie zwei schweren ovalen offenen Ringen als Hort in einem Keramikgefäß gefunden (von Brunn 1959, 63) (Abb. 37). Nackenkammäxte sind in Südosteuropa, vor

Abb. 36 Das einzigartige frühe Tüllenbeil von Kütten-Drobitz, Saalekreis, zeigt, wie die Sächsischen Randleistenbeile geschäftet und umschnürt waren.

Fig. 36 *The unique early socketed axe from Kütten-Drobitz, Saalekreis district, shows how the Saxonian flanged axeheads were hafted and tied.*

As	Se	Ag	Sn	Sb	Te	Au	Pb	Bi
0,02	< 0,005	0,024	10,3	0,008	< 0,005	< 0,01	0,11	< 0,01
0,09	< 0,005	0,040	9,9	0,016	< 0,005	< 0,01	0,05	< 0,01
1,25	< 0,005	1,00	6,5	0,96	0,005	< 0,01	0,01	0,04
1,52	< 0,005	0,98	5,9	1,10	< 0,005	< 0,01	< 0,01	0,05
0,77	–	0,88	7,4	0,75	–	< 0,01	< 0,01	0,028

$^{206}Pb/^{204}Pb$ 2σ	$^{208}Pb/^{204}Pb$ calc.	$^{208}Pb/^{204}Pb$ 2σ	$^{207}Pb/^{204}Pb$ calc.	$^{207}Pb/^{204}Pb$ 2σ
0,001	38,229	0,003	15,646	0,001
0,001	38,471	0,001	15,657	0,001
0,001	38,480	0,001	15,658	0,001

Tab. 8a–b Ergebnisse der Spurenelementanalysen (a) und Bleiisotopenanalysen (b) der mitteldeutschen »anglo-irischen« Beile.

Tab. 8a–b *Results of the trace element analyses (a) and lead isotopic analyses (b) of the Central German »Anglo-Irish« axes.*

allem aber im östlichen Karpatenbecken verbreitet. Die frühe Form I, zu der die Axt von Naumburg zählt, datiert in Bz A1b/A2a (Billig 1957, 293 f.; Mozsolics 1967, 17–24; David 2013, 96 f.). Das Kupfer entspricht dem in der mitteldeutschen Aunjetitzer Kultur verwendeten Material und stammt vermutlich aus dem Slowakischen Erzgebirge. Bei der Axt mit einer stumpfen Schneide handelt es sich vermutlich um einen Import, der nicht nur als Waffe, sondern auch als Rang- oder Würdezeichen diente (Schwarz 2023).

Schließlich ist auch die leider verschollene geometrisch verzierte Axt aus Löbschütz, Lkr. Meißen, erwähnenswert (Billig 1957, 304; Billig 1958, 146 f.) (Abb. 38). Sie gehört dem nordischen Typ Fårdrup an; und da sich seine Verbreitung auf Südskandinavien und Norddeutschland beschränkt, liegt hier ein Importfund flussaufwärts entlang der Elbe vor. Die Axt gehört zeitlich in die späteste Phase der Aunjetitzer Kultur oder in die Zeit nach ihrem Zusammenbruch (Bz A2c–B1; u. a. Vandkilde 1996, 227–229; Nørgaard u. a. 2023). Der Fund verdeutlicht die rasche Entstehung des Nordischen Kreises am Ende der Aunjetitzer Kultur, die zuvor vermutlich den Austausch zwischen dem Norden und Süden kontrollierte. Darüber hinaus zeigt er, dass im Rahmen der für seine Genese entscheidenden Kontakte mit dem Donauraum und Karpatenbecken in Einzelfällen sogar hochrangige Objekte über die Grenzen des Nordischen Kreises hinausgelangten (Meller 2013, 521–523; Vandkilde 2014).

Eindeutig in den Kontext der Fürsten gehört das goldene Beil aus dem Goldfund von Dieskau, der möglicherweise während der Abtragung des Bornhöck daraus entwendet und seine Herkunft verschleiert wurde (Abb. 39). Neben dem Beil enthält er noch zwei gerippte Armbänder, einen verzierten offenen Armring und einen kleinen Ösenring; die übrigen acht archivalisch erwähnten Funde sind unbekannt. Das Gesamtgewicht betrug wohl ca. 1,8 kg (Meller 2019a; Meller 2020; vgl. Filipp/Freudenreich 2014). Das Beil entspricht in der Form dem Typ Langquaid II und datiert somit in die Stufe Bz A2b (Abels 1972, 35–41). Waffen aus Edelmetall stellen in Mitteleuropa exzeptionelle Funde dar. Neben dem Goldbeil aus Dieskau ist lediglich noch ein frühbronzezeitlicher Dolch aus Inowrocław, Woj. Kujawsko-Pomorskie (Polen), bekannt (Primas 1988; Hansen 2001; Meller/Bunnefeld 2020).

5.4 Steinäxte

Außerdem zu nennen sind Äxte und gelochte Schuhleistenkeile aus Stein, die in unterschiedliche Phasen des Neolithikums datieren und in den Fürstengräbern von Leubingen und Helmsdorf, aber auch in den zum Teil nicht hinreichend dokumentierten Hügelgräbern von Königsaue, Salzlandkreis (u. a. Höfer 1906a, 89 f. Taf. 6,7–8; Zich 2016, 392 Nr. 16), Hedersleben, Lkr. Harz (u. a. Höfer 1906a, 88 f. Fig. 180–182; Zich 2016, 391 Nr. 11), Kalbsrieth (»Derfflinger Hügel«), Kyffhäuserkreis (u. a. Möller 1912; Zich 1996, 446 Nr. E377), und Hohenbergen (u. a. Fröhlich 1983, 24 f.; 198 Taf. 63, A1–3.5; Zich 2016, 393 Nr. 28) auftreten (Abb. 40). Entsprechende Grabfunde datieren von der frühen und klassischen Aunjetitzer Kultur (AK 2–3; Leubingen, Helmsdorf, Königsaue, Hedersleben, Kalbsrieth) bis in ihre Spätphase (AK 5; Hohenbergen: Schwarz 2021, 201 f.; 208). Selten finden sich Steinäxte und -beile auch in Flachgräbern, so wie in Wolmirstedt, Lkr. Börde, zusammen mit einem Dolch (Hubensack 2018, 249). Vielfach scheint es sich aber eher um zufällige Bestandteile der Grubenfüllung zu handeln (Hubensack 2018, 111). Die gezielte und regelhafte Beigabe von deutlich älteren Steinäxten ist offenbar auf herausgehobene Bestattungen beschränkt und kann deshalb als Legitimationsstrategie, wohl auf eine mythische Vergangenheit verweisend, interpretiert werden (Meller 2019c, 251 f.; vgl. Fischer 1956, 188 f.).

In den meisten Aunjetitzer Siedlungen Sachsen-Anhalts sind Steinbeile gefunden worden (s. Beitrag Meinecke u. a. in diesem Band), was ein Hinweis auf ihren Gebrauch noch in der frühen Bronzezeit ist. Schmiedehämmer wurden in der frühen Bronzezeit aus Stein hergestellt und weisen in vielen Fällen ebenfalls eine Beilform auf (Hundt 1975; Eguíluz u. a. im Druck). Ob es sich bei diesen Geräten um weiter- bzw. wiederverwendete neolithische Beile handelte, die in jener Zeit sicher in großer Zahl an der Oberfläche zu finden

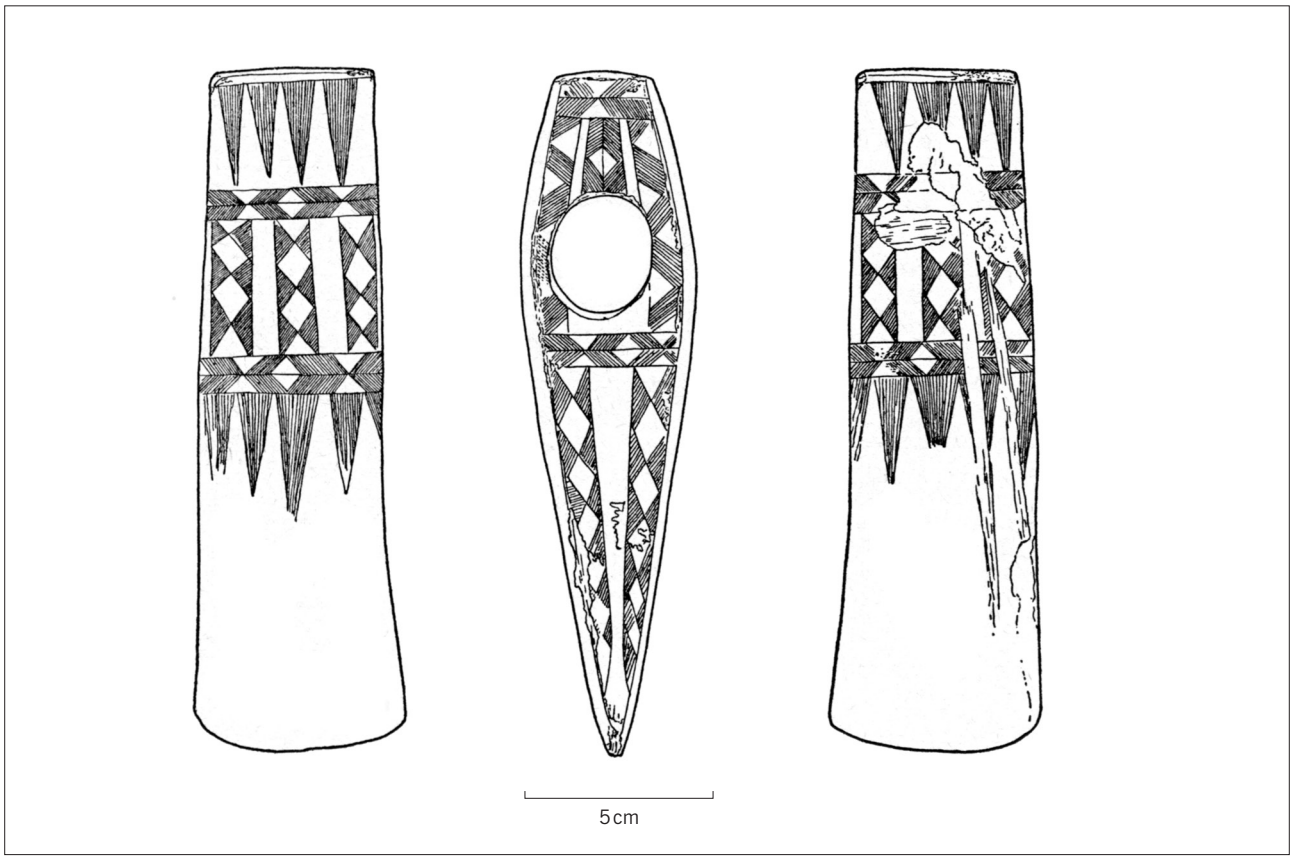

Abb. 38 Die Fårdrup-Axt aus Löbschütz, Lkr. Meißen, wurde aus dem entstehenden Nordischen Kreis elbaufwärts importiert. Südskandinavien gelangte erst mit dem Zusammenbruch der Aunjetitzer Kultur zur Blüte, wobei Metalle und Einflüsse über die Flusssysteme von Elbe und Oder von Süden nach Norden transportiert wurden.

Fig. 38 *The Fårdrup axe from Löbschütz, Meißen district, was imported from the emerging Nordic Bronze Age, from where it travelled up the river Elbe. Southern Scandinavia only flourished after the Únětice Culture's collapse; metals and influences travelled along the river systems of Elbe and Oder from south to north.*

waren, kann derzeit nicht beantwortet werden. Aufgrund ihrer geringen Häufigkeit in den bronzezeitlichen Siedlungen muss ihre wirtschaftliche Bedeutung jedoch begrenzt gewesen sein.

6. Schlussfolgerungen

Die Vielzahl und Vielfalt der vorgestellten Beile und Äxte in der mitteldeutschen Aunjetitzer Kultur verdeutlichen, dass diese auf unterschiedlichen Ebenen von großer Bedeutung waren. Dabei lassen sich die Stücke etwa den Bedeutungsfeldern Werkzeug, Waffe, Statussymbol, Würdezeichen, Exotika und Legitimation zuordnen, natürlich ohne dass diese klar voneinander abzugrenzen wären. Die verschiedenen Funde sind im gesamten Gebiet der mitteldeutschen Aunjetitzer Kultur verbreitet. Zwar ist mit den großen Beilhorten, dem Bornhöck und dem Goldfund von Dieskau ein eindeutiges Machtzentrum in der Mikroregion Dieskau auszumachen, aber in geringerer Anzahl sind Beile, Statussymbole und Würdezeichen auch in anderen Regionen vorhanden (s. Beitrag Schimerová et al. in diesem Band). Auch im Vergleich zu anderen Regionen Mitteleuropas sticht die Circumharzer Gruppe heraus, vor allem aber die Mikroregion um Dieskau (Abb. 41). Dies unterstreicht die außergewöhnliche politische und gesellschaftliche Entwicklung in der Frühbronzezeit, die hier durch die Hortfunde, aber auch die Fürstengräber und Beobachtungen zur Siedlungs- und Wirtschaftsweise erkennbar wird[40].

Die üblichen Sächsischen Randleistenbeile, die vor allem in Hortfunden auftreten, können aufgrund ihrer Gebrauchsspuren nach jetzigem Stand als Werkzeuge und Waffen interpretiert werden, wobei noch experimentelle Untersuchungen durchzuführen sind[41]. Die Kombination aus Werkzeug und Waffe ist für Objekte aus urgeschichtlichen und

Abb. 37 (linke Seite) Die Nackenkammaxt aus Naumburg, Burgenlandkreis, wurde wahrscheinlich aus dem Südosten importiert und diente nicht nur als Waffe, sondern auch als Rang- oder Würdezeichen.

Fig. 37 (left page) *The crest-butted axe from Naumburg, Burgenlandkreis district, was probably imported from the southeast and served not only as a weapon but also as a sign of rank and dignity.*

40 Zu letzteren Aspekten vgl. z. B. Risch u. a. 2021; Risch u. a. 2021a; Risch u. a. 2022.

41 Billig 1957, 310; Kienlin 2006, 470 f.; Meller 2013, 519; Schwarz 2014, 726; 729; Meller 2015; Meller 2017; Schwarz 2019.

1 cm

Abb. 40 In einer Reihe von herausragenden Bestattungen fanden sich neolithische Steinäxte und gelochte Schuhleistenkeile, die mehrere Jahrhunderte bis einige Jahrtausende älter datieren. Sie könnten zur Legitimation von Herrschaft gedient haben. 1 Leubingen, Lkr. Sömmerda; 2 Helmsdorf, Lkr. Mansfeld-Südharz; 3 Königsaue, Salzlandkreis; 4 Hedersleben, Lkr. Harz; 5 Kalbsrieth (»Derfflinger Hügel«), Kyffhäuserkreis; 6 Hohenbergen (= Österkörner), Unstrut-Hainich-Kreis.

Fig. 40 *Neolithic stone axes and perforated shoe-last celts that, at the time of their deposition, were already several hundred to a few thousand years old have been found in a number of outstanding burials. They might have served to legitimise rule. 1 Leubingen, Sömmerda district; 2 Helmsdorf, Mansfeld-Südharz district; 3 Königsaue, Salzlandkreis district; 4 Hedersleben, Harz district; 5 Kalbsrieth (»Derfflinger Hügel«), Kyffhäuserkreis district; 6 Hohenbergen (= Österkörner), Unstrut-Hainich district.*

Abb. 39 (linke Seite) Das goldene Beil aus dem Goldfund von Dieskau, Saalekreis, könnte ursprünglich aus einem Fürstengrab im monumentalen, aber im 19. Jh. abgetragenen Grabhügel Bornhöck stammen. Auf jeden Fall war es ein herausragendes Statussymbol. Edelmetallwaffen sind vom Vorderen Orient bis nach Südosteuropa bekannt, aber in Mitteleuropa nur zweimal belegt (Kopie; Original im Puschkin-Museum Moskau, Russland).

Fig. 39 (left page) *The gold axe from the gold hoard of Dieskau, Saalekreis district, might stem from a princely grave in the monumental burial mound Bornhöck, which was cleared away in the 19th century. It must have been an exceptional status symbol. Weapons made of precious metal are found from the Near East to Southeastern Europe, but only two specimens are known for Central Europe (copy; original find stored in the Pushkin State Museum of Fine Arts, Moscow, Russia).*

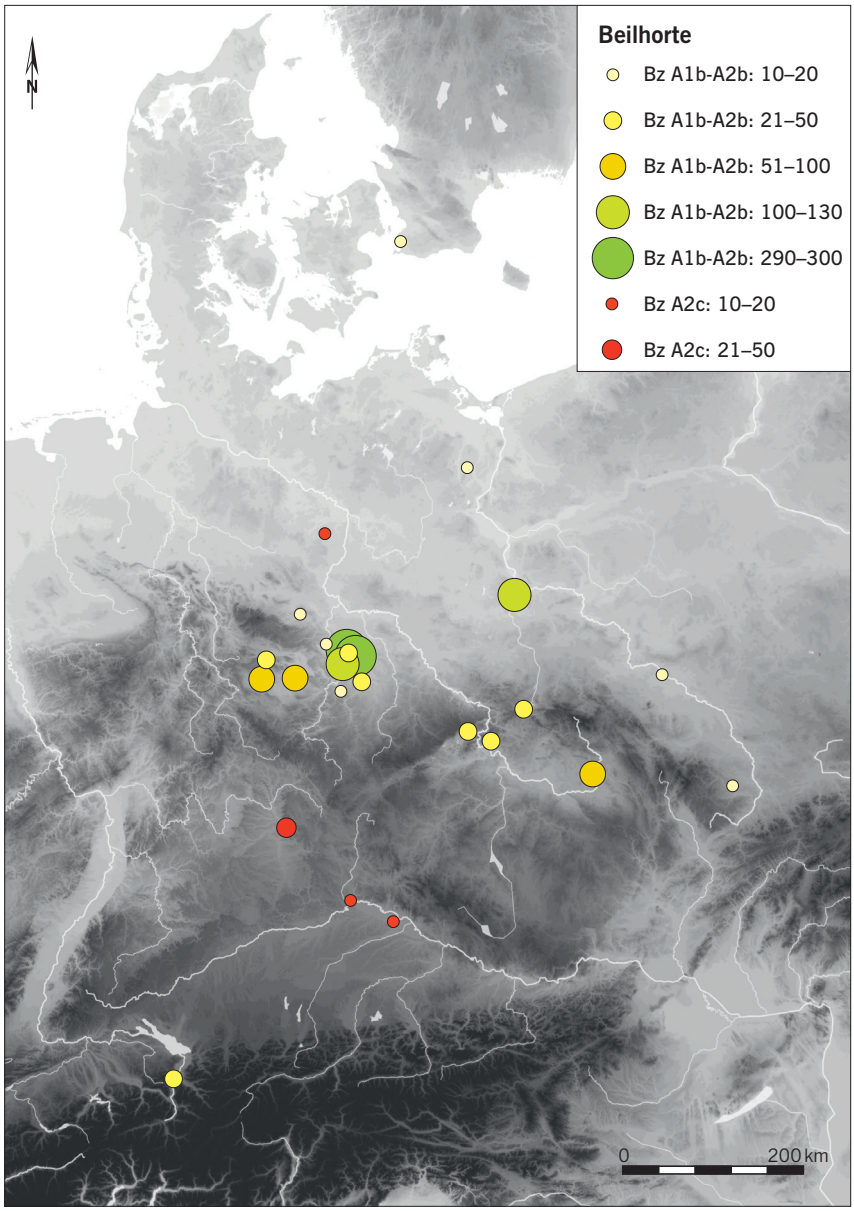

Abb. 41 Verbreitung von frühbronzezeitlichen Hortfunden mit zehn oder mehr Beilen (vgl. Liste 5).

Fig. 41 *Distribution map of Early Bronze Age hoards containing ten or more axes (see List 5).*

ethnografischen Kontexten keineswegs ungewöhnlich (vgl. Feest 2019). Zudem wurden Soldaten in einigen historischen Kontexten beispielsweise zu Bauarbeiten herangezogen, wie es besonders gut für die römischen Legionäre bezeugt ist (Junkelmann 2003, 142 f.). Zu vermuten ist daher, dass auch die Kämpfer der Aunjetitzer Fürsten im alltäglichen Dienst mit ihren Beilen nicht nur trainierten und bei Bedarf kämpften, sondern außerdem damit z. B. Holz bearbeiteten. Bei einem ausschließlichen Gebrauch der Beile als Waffe wäre hingegen eine deutlich geringere Abnutzung zu erwarten, wie es bei den eindeutig als Waffen genutzten nordischen Absatzbeilen der Fall ist (Willroth 2011, 282; Vandkilde 2013, 44). Bemerkenswert ist die Beobachtung, dass die Beile der einzelnen Hortfunde, sofern sie benutzt worden sind, zuletzt auf ähnliche Weise eingesetzt wurden. Trotz ihres ungleichen Abnutzungsgrades spricht dies für einen gemeinsamen letzten Einsatz.

Die Sächsischen Randleistenbeile verfügen über relativ einheitliche Formen mit letztlich geringfügigen Variationen und wurden recht standardisiert aus intensiv überschmiedeten Rohlingen hergestellt. Für den Hortfund Dieskau III kann nachgewiesen werden, dass die Beile zentralisiert und in Serie von jeweils mehreren Händen gefertigt wurden, weshalb zwar eine gewisse Variation erkennbar, aber keine richtige typologische Gliederung möglich ist. Zusammen mit der erwähnten letzten gemeinsamen Nutzung der Beile untermauert diese Beobachtung die Theorie, dass es sich bei den Horten um Niederlegungen durch bewaffnete Truppen der Fürsten handelt, wobei die Beile an die Krieger verliehen wurden (Abb. 42). Gleichzeitig sprechen diese Beobachtungen dagegen, dass Menschen lediglich zur Deponierung ihrer individuell beschafften und gebrauchten Beile zusammenkamen (u. a. Meller 2015; Meller 2017).

Unter den als Statussymbole und Würdezeichen interpretierten Beilen und Äxten existiert eine deutlich größere Vielfalt. Dazu zählen Beile aus Gräbern, die zumeist aus Zinnbronze bestehen und sowohl Waffen als auch goldfarbene Statussymbole herausgehobener Krieger darstellen (Meller 2019b), und seltene (gerippte »Doppeläxte«), einzigartige (Kütten-Dobritz) sowie fremdartige Formen (Naumburg,

westeuropäische Randleistenbeile und ihre Imitationen, Axt vom Typ Fårdrup, neolithische Steinäxte). Offenbar spielten Insignien im frühbronzezeitlichen Mitteldeutschland eine gewisse Rolle, wie es diese Beile und Äxte, der einzigartige »Zinken« von Welbsleben, Lkr. Mansfeld-Südharz, aber auch die Stabdolche mit einer primären Funktion als Waffen zeigen (vgl. Zich 2016, 373; 385–390; Meller 2024).

In außergewöhnlichen Bestattungen, darunter den Fürstengräbern von Leubingen und Helmsdorf, wurde mittels der Steinäxte ein Bezug zur Vergangenheit, womöglich auf heroische bzw. mythische Ahnen demonstriert. Darüber hinaus wurde durch zinnbronzene Waffen, in Leubingen sogar mit einer »Überausstattung«, unmissverständlich die Verkörperung martialischer und militärischer Werte ausgedrückt. Zu den Äxten und Beilen treten in einigen Fällen weitere Waffen wie Streitmeißel, Dolche, in Leubingen sogar ein Stabdolch, goldener Schmuck, der im Fall der Fürstengräber einen festen Ornat ergibt, und weitere legitimierende Bezüge auf Traditionen und Orte der Vergangenheit (Meller 2019; Meller 2019c). Den Höhepunkt stellt sicherlich das goldene Beil aus Dieskau dar, das womöglich ursprünglich im monumentalen Grabhügel Bornhöck entdeckt wurde (Meller 2019a; Meller 2020). Eine Reminiszenz an die Tradition doppelter Waffen, wie sie in Leubingen greifbar ist, stellen die jeweils zwei prunkvollen Schwerter und gewöhnlichen Beile aus dem Hort von Nebra, Burgenlandkreis, dar (Meller 2010, 57–59; Hansen 2010, 83–85).

Mit Ausnahme der neolithischen Steinäxte sowie der wenigen Beile und Stabdolche aus Gräbern stammen die übrigen Statussymbole und Würdezeichen ebenso wie die einfachen Randleistenbeile aus Deponierungen, zumeist Hortfunden. Wahrscheinlich repräsentieren sie keinen persönlichen oder personalisierten Besitz und wurden deshalb nicht ins Grab mitgegeben, sondern zu bestimmten Anlässen in der Erde deponiert (vgl. Fontijn 2002, 26 f.)[42]. Vor dem Hintergrund des Aunjetitzer Herrschaftssystems könnten ihre Träger daher als »Amtsträger« bzw. »Offiziere« gedeutet werden (Bunnefeld 2019; Meller 2019b). Die Fundstücke wurden unbeschädigt, aber mit entfernten bzw. teils abgebrochenen Schäften niedergelegt. Insbesondere eindeutig fremde Formen gelangten niemals in die Gräber[43]. Die einfachen Randleistenbeile wurden mit bis zu 300 Stücken in der Regel in Keramikgefäßen niedergelegt. Im Hort von Schkopau hingegen wurden die Beile dem frühen Bericht zufolge im Kreis mit ihren Schneiden nach innen weisend deponiert (von Brunn 1959, 66). Während viele Horte aus unterschiedlichen Objektarten bestehen, enthalten einige ausschließlich eine größere Anzahl von Beilen (von Brunn 1959). Ausnahmsweise finden sich darin auch außergewöhnlich große Beile. In manchen Fällen wie Halle-Kanena III wurden Halbfabrikate neben fertigen und benutzten Beilen niedergelegt. Neben den einfachen Beilen wurden teilweise auch andere Objekte zu mehreren Exemplaren niedergelegt und repräsentieren dann wohl Gruppen von »Amtsträgern« bzw. »Offizieren«. Dies betrifft die gerippten »Doppeläxte« – stets paarweise oder einzeln deponiert – und Stabdolche (Bunnefeld 2019; Meller 2019b).

Die sehr umfangreiche Forschungsgeschichte zur Interpretation der Deponierungen kann an dieser Stelle nicht ausführlich dargestellt werden[44]. Die Aunjetitzer Horte in Mitteldeutschland wurden als Versteckfunde in unruhigen Zeiten (von Brunn 1950, 249–251), Verwahrfunde (Otto 1955, 45–47) und später – dem allgemeinen Trend folgend – als kultische Niederlegungen angesehen (Maraszek 2019, 94). D. Fontijn versucht diese recht strikte Trennung aufzuweichen und deutet Deponierungen als teils permanent, teils eher zeitlich befristet intendierte Niederlegung von Werten, um sie aus der Sphäre ökonomischen Wertes in eine Sphäre kultureller Werte zu transferieren (Fontijn 2019, 86–111). Meller und Schwarz interpretieren die Horte als Zeugnis von bewaffneten Truppen im Dienst der Aunjetitzer Fürsten, deren Inhalt auf diese Weise verwahrt oder aber zu bestimmten Anlässen, etwa beim Tod eines Fürsten, niedergelegt wurde[45].

Neuere Forschungen zeigen, dass die Hortfunde der Circumharzer Gruppe, sofern die genaueren Umstände bekannt sind, anscheinend regelhaft im Siedlungskontext gefunden wurden (Bunnefeld/Meller in Vorb.). Aus diesem Grund ist nicht damit zu rechnen, dass in jedem Fall permanente Deponierungen beabsichtigt waren. Die Gründe für die Niederlegungen bleiben unsicher und es ist keineswegs zwingend, dass alle Horte aus derselben Intention angelegt wurden. Es könnte sich zum Teil einerseits um eine Art »Rüstkammern« handeln, aus denen bei Bedarf die bewaffneten Truppen der Fürsten ausgestattet wurden, wobei möglicherweise jeder Kämpfer einen seinen Körpermaßen angepassten Holzschaft besaß (Schwarz 2014, 726–728). Eine kreisförmige Niederlegung, wie sie in Schkopau beobachtet wurde, passt hierzu allerdings nicht. Es ist daher andererseits möglich, dass es sich um rituelle Deponierungen beispielsweise anlässlich der Bestattung eines Fürsten handelte, in deren Verlauf sein Nachfolger die Kämpfer mit neuen Waffen ausstattete und sich ihre Loyalität sicherte (z. B. Meller 2015, 248; Meller 2019, 62). Offen bleibt allerdings derzeit, wie die Halbfabrikate in dieses Bild passen. Andere Horte könnten vielleicht auch zur zeitweiligen Verwahrung hochrangiger Objekte gedient haben, z. B. bis zum nächsten repräsentativen Anlass oder bis zur Bestimmung neuer »Amtsträger«.

Unabhängig von der detaillierten Interpretation der Deponierungen lässt sich zusammenfassen, dass Beile und Äxte in der mitteldeutschen Aunjetitzer Kultur verschiedene wichtige Funktionen erfüllten. Während die Sächsischen Randleistenbeile zentralisiert hergestellte und gemeinsam genutzte Werkzeuge und Waffen waren, existierte zusätzlich eine Reihe von Beilen und Äxten als reine Waffen, Würdezeichen und Insignien, die zum Teil der Herrschaftsrepräsentation und -legitimation dienten.

42 Andererseits ist nicht auszuschließen, dass dennoch ein Zusammenhang mit bestatteten Personen(-gruppen) besteht, die aus einer jenseitigen Existenz Zugriff auf niedergelegte Objekte haben sollten (Schwarz 2014, 734; Schwarz 2021, 201).

43 Die Randleistenbeile aus Gräbern haben zwar zum Teil ungewöhnliche Formen, waren allerdings, insbesondere im geschäfteten Zustand, nicht unbedingt eindeutig als fremd zu identifizieren.

44 Mit Blick auf die Beile siehe z. B. Kienlin 2008, 293–297.

45 Meller 2013, 520–523; Meller 2015; Schwarz 2014, 726–729; Meller 2017; Meller 2019b; Risch u. a. 2021; Schwarz 2019, 130; Schwarz 2021, 201.

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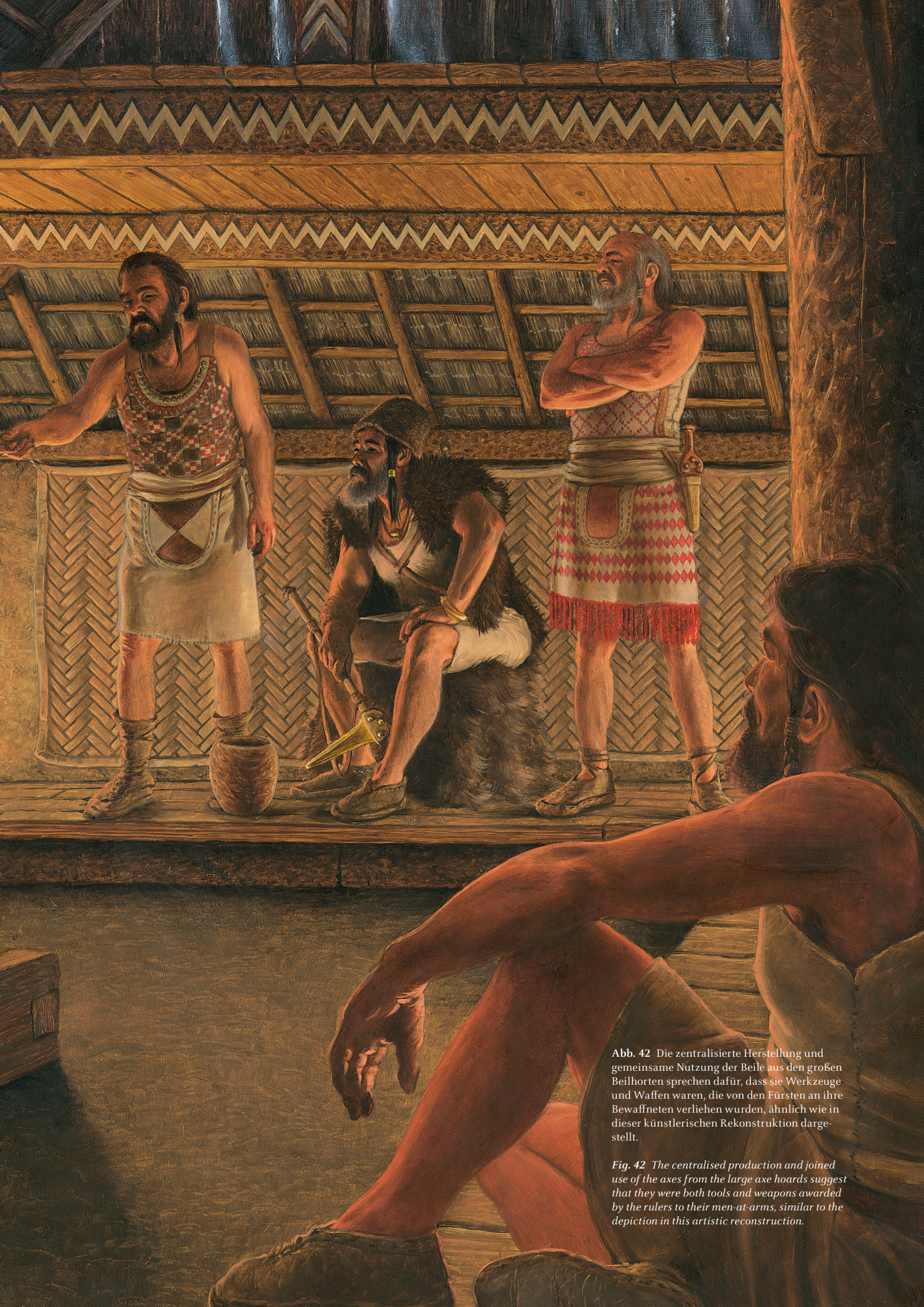

Abb. 42 Die zentralisierte Herstellung und gemeinsame Nutzung der Beile aus den großen Beilhorten sprechen dafür, dass sie Werkzeuge und Waffen waren, die von den Fürsten an ihre Bewaffneten verliehen wurden, ähnlich wie in dieser künstlerischen Rekonstruktion dargestellt.

Fig. 42 *The centralised production and joined use of the axes from the large axe hoards suggest that they were both tools and weapons awarded by the rulers to their men-at-arms, similar to the depiction in this artistic reconstruction.*

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Abbildungsnachweis

1 A. Swieder, LDA; Datengrundlage: Verf.; Kartengrundlage: »version 3« basierend auf 3 arc second SRTM V2, zur Verfügung gestellt vom International Center for Tropical Agriculture (CIAT) Land Use Project, mit freundl. Genehmigung des U.S. Geological Survey (USGS) und der National Aeronautics and Space Administration (NASA), public domain; Gewässer (WISE) mit freundl. Genehmigung der European Environment Agency (EEA), Lizenz CC-BY 4.0; Aunjetitzer Kultur: LDA; Detailkarte: DGM25 © GeoBasis-DE / LVermGeo LSA, Datenlizenz Deutschland – Namensnennung – Version 2.0; Flüsse entnommen aus der Database of Global Administrative Areas (GADM) version 1.0, CC BY-NC-SA 3.0 US

2 Entwurf: R. Risch, Barcelona; Grafik: B. Janzen, LDA

3 1–8 C. Gembalski, Halle (Saale); 9–10 S. Belizki, Halle [Saale])

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12 Foto: F. Hertel, LDA; Schmiedeversuche Herbert R. Bauer, Halle (Saale)

13 Foto: LDA

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31 © H. Arnold, Thüringer Landesamt für Denkmalpflege und Archäologie, Weimar
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33 A. Swieder, LDA; Datengrundlage: ergänzt nach Jockenhövel 2004; Kartengrundlage: »version 3« basierend auf 3 arc second SRTM V2, zur Verfügung gestellt vom International Center for Tropical Agriculture (CIAT) Land Use Project, mit freundl. Genehmigung des U.S. Geological Survey (USGS) und der National Aeronautics and Space Administration (NASA), public domain; Gewässer (WISE) mit freundl. Genehmigung der European Environment Agency (EEA), Lizenz CC-BY 4.0
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42 K. Schauer, Salzburg

Tab. 1–7 Verf.
Tab. 8 Verf.; Analysen: CEZA Mannheim; Schweta: Krause 2003, CD-Rom

Liste 1 Verf.
Liste 2–3 nach von Brunn 1950; Billig 1961
Liste 4 nach Jockenhövel 2004, ergänzt
Liste 5 Verf.

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Liste 1: Fundliste der Beilhorte und Äxte in Mitteldeutschland

Nummer	Fundort	Fundart	Literatur
1	Löbschütz, Lkr. Meißen	Einzelfund	Billig 1957, 304; Billig 1958, 146 f.
2	Weßmar, Saalekreis	Einzelfund	Billig 1957, 288–290
3	Hedersleben, Lkr. Harz	Grab	Höfer 1906a, 88 f.
4	Helmsdorf, Lkr. Mansfeld-Südharz	Grab	Größler 1907
4	Helmsdorf, Lkr. Mansfeld-Südharz	Grab	Größler 1907
5	Hohenbergen, Unstrut-Hainich-Kreis	Grab	Zich 2016, 393 Nr. 28
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6	Kalbsrieth, Kyffhäuserkreis	Grab	Zich 1996, 446 Nr. E377
7	Königsaue, Salzlandkreis	Grab	Zich 2016, 392 Nr. 16
8	Leubingen, Lkr. Sömmerda	Grab	Klopfleisch 1878; Höfer 1906
8	Leubingen, Lkr. Sömmerda	Grab	Klopfleisch 1878; Höfer 1906
9	Naundorf, Lkr. Meißen	Grab	Zich 1996, 533 Nr. K161
10	Naundorf, Lkr. Meißen	Grab	Zich 1996, 534 Nr. K163
11	Nobitz, Lkr. Altenburger Land	Grab	Zich 1996, 217; 509 Nr. H5
12	Osmünde, Saalekreis	Grab	Zich 1996, 428 Nr. E137 [‘Dieskau’]
13	Osmünde, Saalekreis	Grab	Meller 2014, 696 f. Nr. 16
14	Schkeuditz, Lkr. Nordsachsen	Grab	Rummer u. a. 2018
15	Walschleben, Lkr. Sömmerda	Grab	Zich 1996, 504 Nr. F293
16	Wolmirstedt, Lkr. Börde	Grab	Hubensack 2018, 249
17	Dieskau 1, Saalekreis	Grab (?)	Meller 2019a; Meller 2020
18	Großheringen, Lkr. Weimarer Land	Grab (?)	Zich 1996, 495 Nr. F152
19	Baschütz-Nadelwitz, Lkr. Bautzen	Hort	von Brunn 1959, 54
20	Benndorf, Lkr. Mansfeld-Südharz	Hort	Unpubliziert
21	Dederstedt 1, Lkr. Mansfeld-Südharz	Hort	von Brunn 1959, 55
22	Dermsdorf, Lkr. Sömmerda	Hort	Küßner/Wechler 2019
23	Dieskau 2, Saalekreis	Hort	von Brunn 1959, 55 f.
24	Dieskau 3, Saalekreis	Hort	von Brunn 1959, 56
25	Domsen, Burgenlandkreis	Hort	Ganslmeier 2019, 337 f.
26	Dresden-Prohlis	Hort	von Brunn 1959, 56
27	Freiroda, Burgenlandkreis	Hort	Meller 2013, 516 f. Tab. 2
28	Friedrichsaue, Salzlandkreis	Hort	Meller 2013, 516 f. Tab. 2
29	Giersleben, Salzlandkreis	Hort	von Brunn 1959, 57
30	Griefstedt, Lkr. Sömmerda	Hort	von Brunn 1959, 57
31	Gröbers-Bennewitz 1, Saalekreis	Hort	von Brunn 1959, 57 f.
32	Halle (Saale)	Hort	von Brunn 1959, 58 f.
33	Halle-Kanena 2	Hort	von Brunn 1959, 59
34	Halle-Kanena 3	Hort	von Brunn 1959, 59
35	Halle-Reideburg	Hort	von Brunn 1959, 59
36	Hausneindorf, Lkr. Harz	Hort	von Brunn 1959, 59
37	Helfta 1, Lkr. Mansfeld-Südharz	Hort	von Brunn 1959, 59 f.
38	Jena	Hort	von Brunn 1959, 60
39	Kläden, Lkr. Stendal	Hort	von Brunn 1959, 61
40	Kriebitzsch, Lkr. Altenburger Land	Hort	von Brunn 1959, 61
41	Krüden, Lkr. Stendal	Hort	von Brunn 1959, 61
42	Kütten-Drobitz 1, Saalekreis	Hort	von Brunn 1959, 61 f.
43	Mehringen 1, Salzlandkreis	Hort	von Brunn 1959, 62

Nummer	Fundort	Fundart	Literatur
44	Meineweh, Burgenlandkreis	Hort	von Brunn 1959, 62
45	Milzau-Burgstaden, Saalekreis	Hort	von Brunn 1959, 62
46	Mittelhausen, Stadt Erfurt	Hort	von Brunn 1959, 62
47	Naumburg, Burgenlandkreis	Hort	von Brunn 1959, 63
48	Nebra, Burgenlandkreis	Hort	Meller 2010; Meller 2013
49	Neunheilingen, Unstrut-Hainich-Kreis	Hort	von Brunn 1959, 63
50	Nieder Neundorf, Lkr. Görlitz	Hort	von Brunn 1959, 64
51	Olbersdorf, Lkr. Görlitz	Hort	von Brunn 1959, 64
52	Oldisleben, Kyffhäuserkreis	Hort	von Brunn 1959, 64
53	Orlishausen, Lkr. Sömmerda	Hort	von Brunn 1959, 64
54	Osterburg, Lkr. Stendal	Hort	von Brunn 1959, 64
55	Osterfeld-Lissen 2, Burgenlandkreis	Hort	von Brunn 1959, 65
56	Pegau-Carsdorf, Lkr. Leipzig	Hort	von Brunn 1959, 65
57	Schkopau 1, Saalekreis	Hort	von Brunn 1959, 66
58	Schleinitz-Wauden, Lkr. Meißen	Hort	von Brunn 1959, 66 f.
59	Schweta, Lkr. Nordsachsen	Hort	von Brunn 1959, 67
60	Straußberg, Kyffhäuserkreis	Hort	von Brunn 1959, 67
61	Teicha I, Saalekreis	Hort	Bunnefeld/Meller in Vorb.
62	Tilleda, Lkr. Mansfeld-Südharz	Hort	Meller 2013, 516 f. Tab. 2
63	Uhyst, Lkr. Bautzen	Hort	von Brunn 1959, 68
64	Veltheim, Lkr. Wolfenbüttel	Hort	Laux 2000
65	Wurschen, Lkr. Bautzen	Hort	von Brunn 1959, 69
66	Eilenburg, Lkr. Nordsachsen	unbekannt	von Brunn 1959, 57
67	Emersleben, Lkr. Harz	unbekannt	Bunnefeld 2019, 197 Nr. 6

Liste 1 Fundliste der Beilhorte und Äxte in Mitteldeutschland (vgl. Abb. 1).

List 1 *Finds list of the axe hoards and axes in Central Germany (see Fig. 1).*

Liste 2: Zungenförmige plankonvexe Rohlinge

Nummer	Fundort	Beschreibung
1	Freiroda, Burgenlandkreis	zungenförmiger Barren; Länge 10,5 cm; Breite Schneide: 4,0 cm, Gew. 221,5 g; Hortfund; LV Halle (HK 2002:47782)
2	Dresden-Dobritz	recht unförmiger flacher zungenförmiger Barren; Länge ca. 9,4 cm, max. Breite ca. 4,0 cm; Hortfund; von Brunn 1959, 56, Taf. 25,3; Mus. Dresden (S. 138-142/38, verschollen)
3	Dolánky, okr. Louny (Tschechische Republik)	zungenförmiger Barren; Länge 7,0 cm, Breite 3,0 cm; Einzelfund; Moucha 2005, 104 Nr. 27, Taf. 185,8; Mus. České Budějovice (J.I. 71)
4	Hříškov, okr. Louny (Tschechische Republik)	zungenförmiger Barren, Umriss schon leicht beilförmig; Länge 11,1 cm, Breite 4,3 cm, Gew. 305 g; Einzelfund; Moucha 2005, 113 Nr. 54, Taf. 215,9; Mus. Litoměřice (Inv.-Nr. 581, 520 [Sammlung Ankert])

Liste 2 Zungenförmige plankonvexe Rohlinge.

List 2 *Tongue-shaped plano-convex blanks.*

Liste 3: Trapez-/beilförmige bzw. leicht überschmiedete Halbfabrikate

Nummer	Fundort	Beschreibung
1	Dermsdorf, Lkr. Sömmerda	beilförmiger Barren; Länge 12,2 cm; Breite Schneide 4,2 cm, Gew. 192 g; Hortfund; Küßner/Wechler 2019, 454; TLDA (Inv.-Nr. 11/101-112)
2	Meineweh, Burgenlandkreis	beilförmiger Barren (?); Länge 7,2 cm, Breite 2,7 cm; Hortfund (?) (nach von Brunn 1959; laut Ortsakte Meineweh [ID 1732], Bl. 44: »Hügelgrab«); von Brunn 1959, 62, Taf. 58,4; Mus. Zeitz (Inv.-Nr. III/55/5)
3	Milzau-Burgstaden, Saalekreis	beilförmiger Barren; Länge 12,6 cm, Breite Bahn ca. 3,0 cm, Breite Schneide 4,7 cm, Gew. 316 g; Hortfund; von Brunn 1959, 62, Taf. 59,9; LV Halle (HK 45:22a)
4	Milzau-Burgstaden, Saalekreis	zungenförmiger Barren; Länge 10,6 cm, Breite max. 2,8 cm, Gew. 149 g; Hortfund; von Brunn 1959, 62, Taf. 59,8; LV Halle (HK 45:22b)
5.	Naumburg, Burgenlandkreis	beilförmiger Barren; Länge 8,5 cm, Breite Bahn ca. 2,6 cm, Breite Schneide 3,7 cm, Gew. 216 g; Hortfund; von Brunn 1959, 63, Taf. 64; LV Halle (HK 56:955c)
6	Oldisleben, Kyffhäuserkreis	beilförmiger Barren; Länge ca. 10,2 cm, Breite Bahn ca. 2,2 cm, Breite Schneide ca. 4,6 cm; Hortfund; von Brunn 1959, 64, Taf. 70; angeblich LV Halle (verschollen)
7	Schkopau, Saalekreis	beilförmiger Barren; Länge 9,2 cm, Breite Schneide: 3,6 cm, Gew. 195 g; LV Halle (HK 7330)
8	Nieder Neundorf, Lkr. Görlitz	beilförmiger Barren; Länge ca. 9,0 cm, Breite Bahn ca. 2,4 cm, Breite Schneide ca. 4,0 cm; Hortfund; von Brunn 1959, 64, Taf. 68; Pernicka u. a. 1999, 5 f.; Mus. Görlitz (S. 27-69/49)
9	Straubing	»Beilbarren« (?); Länge 9,1 cm; Einzelfund; Hundt 1958, 58, Taf. 50,3; Mus. Straubing (Inv.-Nr. 1626).
10	Jičíněves, okr. Jičín (Tschechische Republik)	in offener Form gegossener beilförmiger Barren; Länge 10,0 cm, Breite 3,6 cm; Hortfund; Moucha 2005, 115 Nr. 59, Taf. 73,15; Mus. Kopidlno (A 162)
11	Očihov, okr. Louny (Tschechische Republik)	beilförmiger Barren; Länge 10,6 cm, Breite 4,4 cm; Einzelfund; Moucha 2005, 135 Nr. 140, Taf. 215,10; Mus. Chomutov (Inv.-Nr. 131)
12	Předměřice nad Labem, okr. Hradec Králové (Tschechische Republik)	beilförmiger Barren; Einzelfund; Moucha 2005, 145 Nr. 183
13	Soběchleby, okr. Louny (Tschechische Republik)	in offener Form gegossener beilförmiger Barren; Länge 11,6 cm, Breite 4,7 cm; Hortfund; Moucha 2005, 152 f. Nr. 211, Taf. 189,25; NHM Wien (Inv.-Nr. 14375)

Liste 3 Trapez-/beilförmige bzw. leicht überschmiedete Halbfabrikate.

List 3 *Trapezoidal/axe-shaped or, after casting, slightly forged semi-finished products.*

Liste 4: Fundliste der »anglo-irischen« Beile

Nummer	Fundort	Literatur
1	Bei Davrup, Region Sjælland (Dänemark)	Vandkilde 1996, 425 Nr. 263
2	Fåborg, Region Syddanmark (Dänemark)	Vandkilde 1996, 424 f. Nr. 261
3	Flenstofte, Region Syddanmark (Dänemark)	Vandkilde 1996, 424 Nr. 260
4	Fredsø, Region Nordjylland (Dänemark)	Vandkilde 1996, 402 Nr. 34
5	Gallemose, Region Midtjylland (Dänemark)	Vandkilde 1996, 415 f. Nr. 175
6	Holmsland Klit, Region Midtjylland (Dänemark)	Vandkilde 1996, 425 Nr. 268
7	Jordløse, Region Syddanmark (Dänemark)	Vandkilde 1996, 426 Nr. 275
8	Lumby Torp, Region Syddanmark (Dänemark)	Vandkilde 1996, 399 Nr. 3
9	Odder, Region Midtjylland (Dänemark)	Vandkilde 1996, 425 Nr. 267
10	Ørndrup Mark, Mors, Region Nordjylland (Dänemark)	Vandkilde 1996, 425 Nr. 262
11	Palleshave, Region Syddanmark (Dänemark)	Vandkilde 1996, 425 Nr. 264
12	Selchausdal, Region Sjælland (Dänemark)	Vandkilde 1996, 425 Nr. 265
13	Store Heddinge, Region Sjælland (Dänemark)	Vandkilde 1996, 421 Nr. 227

Nummer	Fundort	Literatur
14	Ulstrup, Region Sjælland (Dänemark)	Vandkilde 1996, 425 Nr. 266
15	Fjälkinge, Schonen (Schweden)	Vandkilde 2017, 224
16	Hällesberg, Bohuslän (Schweden)	Vandkilde 2017, 224
17	Kirchspiel Tanum, Bohuslän (Schweden)	Vandkilde 2017, 224
18	Löddeköpinge, Västergötland (Schweden)	Vandkilde 2017, 224
19	Pile, Schonen (Schweden)	Vandkilde 2017
20	See Mogden, Västergötland (Schweden)	Vandkilde 2017, 224
21	Skivarp, Schonen (Schweden)	Vandkilde 2017, 224
22	Västra Frolunda, Västergötland (Schweden)	Vandkilde 2017, 224
23	Ahausen, Lkr. Rotenburg (Wümme)	Laux 2000, 50 f. Nr. 151
24	Ahneby, Lkr. Schleswig-Flensburg	Vandkilde 1996, 89 Abb. 74
25	Dieskau 2, Saalekreis	von Brunn 1959, 55 f.
26	»Düsseldorf«	Kibbert 1980, 75 Nr. 52
27	Griefstedt, Lkr. Sömmerda	von Brunn 1959, 57
28	Herchen, Rhein-Sieg-Kreis	Kibbert 1980, 76 Nr. 56
29	Mainz	Kibbert 1980, 76 Nr. 53; 78 Nr. 61
30	Petershagen, Lkr. Minden-Lübbecke	Kibbert 1980, 76 Nr. 55
31	Pirmasens	Kibbert 1980, 76 Nr. 54
32	Ronnenberg, Region Hannover	Laux 2000, 50 Nr. 150
33	Sassenberg, Lkr. Warendorf	Kibbert 1980, 108 Nr. 114
34	Schweta, Lkr. Nordsachsen	von Brunn 1959, 67
35	Vlotho-Uffeln, Lkr. Minden-Lübbecke	Kibbert 1980, 77 Nr. 57
36	Weßmar, Saalekreis	Billig 1957, 288–290
37	Arnhem, Prov. Gelderland (Niederlande)	Butler 1995/96, 172 Nr. 14
38	Drouwen, Prov. Drenthe (Niederlande)	Butler 1995/96, 173 Nr. 17
39	Gemert, Prov. Noord-Brabant (Niederlande)	Butler 1995/96, 177 Nr. 26
40	Groot Haasdal, Prov. Limburg (Niederlande)	Butler 1995/96, 177 Nr. 25
41	Haler, Prov. Limburg (Niederlande)	Butler 1995/96, 172 Nr. 15
42	Hapert, Prov. Noord-Brabant (Niederlande)	Butler 1995/96, 172 Nr. 16
43	Haren, Prov. Groningen (Niederlande)	Butler 1995/96, 178 Nr. 28
44	Nijmwegen, Prov. Gelderland (Niederlande)	Butler 1995/96, 178 Nr. 29
45	s´Hertogenbosch, Prov. Noord-Brabant (Niederlande)	Butler 1995/96, 178 Nr. 27
46	Wageningen, Prov. Gelderland (Niederlande)	Butler 1995/96, 172 Nr. 13
47	Wijchen, Prov. Gelderland (Niederlande)	Butler 1995/96, 173 Nr. 18
48	Baasrode, Prov. Ostflandern (Belgien)	Jockenhövel 2004, 165
49	Gent, Prov. Ostflandern (Belgien)	Jockenhövel 2004, 165
50	Geraardsbergen, Prov. Ostflandern (Belgien)	Jockenhövel 2004, 165
51	Hastière-par-delà, Prov. Namur (Belgien)	Jockenhövel 2004, 165
52	Rekem, Prov. Limburg (Belgien)	Jockenhövel 2004, 165
53	Vaux-sous-Chévremont, Prov. Lüttich (Belgien)	Jockenhövel 2004, 165
54	Waasmunster, Prov. Ostflandern (Belgien)	Jockenhövel 2004, 165
55	Wichelen, Prov. Ostflandern (Belgien)	Jockenhövel 2004, 165
56	»Somme« (Frankreich)	Jockenhövel 2004, 165
57	Amiens, dép. Somme (Frankreich)	Jockenhövel 2004, 165
58	Bacouel-sur-Selle, dép. Somme (Frankreich)	Jockenhövel 2004, 164
59	Banthelu, dép. Val-d'Oise (Frankreich)	Jockenhövel 2004, 165
60	Borest, dép. Oise (Frankreich)	Jockenhövel 2004, 165

Nummer	Fundort	Literatur
61	Boulogne-sur-Mer, dép. Pas-de-Calais (Frankreich)	Jockenhövel 2004, 165
62	Conchil-le-Temple, dép. Pas-de-Calais (Frankreich)	Jockenhövel 2004, 165
63	Condé-sur-Aisne, dép. Aisne (Frankreich)	Jockenhövel 2004, 165
64	Les Essarts-Varimpré (Callengeville), dép. Seine-Maritime (Frankreich)	Jockenhövel 2004, 165
65	Lille, dép. du Nord (Frankreich)	Jockenhövel 2004, 165
66	Maisnière, dép. Somme (Frankreich)	Jockenhövel 2004, 165
67	Pontavert, dép. Aisne (Frankreich)	Jockenhövel 2004, 165
68	Umgebung von Abbeville, dép. Somme (Frankreich)	Jockenhövel 2004, 165

Liste 4 Fundliste der »anglo-irischen« Beile (vgl. Abb. 33).

List 4 *Finds list of the »Anglo-Irish« axes (see Fig. 33).*

Liste 5: Fundliste der frühbronzezeitlichen Hortfunde mit zehn oder mehr Beilen

Nummer	Fundort	Beile	Literatur
1	Bresinchen, Lkr. Spree-Neiße	103	Breddin 1969
2	Dederstedt 1, Lkr. Mansfeld-Südharz	14	von Brunn 1959, 55
3	Dermsdorf, Lkr. Sömmerda	98	Küßner/Wechler 2019
4	Dieskau 3, Saalekreis	292	von Brunn 1959, 56
5	Gröbers-Bennewitz 1, Saalekreis	297	von Brunn 1959, 57 f.
6	Halle-Kanena 3	48	von Brunn 1959, 59
7	Hausneindorf, Lkr. Harz	10	von Brunn 1959, 59
8	Neunheilingen, Unstrut-Hainich-Kreis	61	von Brunn 1959, 63
9	Olbersdorf, Lkr. Görlitz	49	von Brunn 1959, 64
10	Osterfeld-Lissen 2, Burgenlandkreis	10	von Brunn 1959, 65
11	Pegau-Carsdorf, Lkr. Leipzig	35	von Brunn 1959, 65
12	Schkopau 1, Saalekreis	124	von Brunn 1959, 66
13	Straußberg, Kyffhäuserkreis	35	von Brunn 1959, 67
14	Kukleny, okr. Hradec Králové (Tschechische Republik)	57	Schimerová u. a. 2023; siehe Beitrag Schimerová u. a. in diesem Band
15	Soběchleby, okr. Louny (Tschechische Republik)	30+	Moucha 2005, 152-154 Nr. 211
16	Soběnice, okr. Litoměřice (Tschechische Republik)	40	Moucha 2005, 154 f. Nr. 212
17	Pilszcz, woj. Opolskie (Polen)	20	Szpunar 1987
18	Wrocław-Pilczyce, woj. Dolnośląskie (Polen)	11	Szpunar 1987
19	Falkenwalde, Lkr. Uckermark	12	Zich 1996, 368 Nr. B18
20	Pile, Schonen (Schweden)	13	Vandkilde 2017
21	Salez-Sennwald, Kt. St. Gallen (Schweiz)	25+	Abels 1972
22	Kläden, Lkr. Stendal	10	von Brunn 1959, 61
23	Forchheim-Serlbach, Lkr. Forchheim	22	Pászthory/Mayer 1998
24	Paitzkofen, Lkr. Straubing-Bogen	10	Pászthory/Mayer 1998
25	Regensburg-Hochweg	20	Pászthory/Mayer 1998

Liste 5 Fundliste der frühbronzezeitlichen Hortfunde mit zehn oder mehr Beilen (vgl. Abb. 41).

List 5 *Finds list of the Early Bronze Age hoards containing ten or more axes (see Fig. 41).*

Eine frühbronzezeitliche Siedlungsgrube mit Beilgießform und Flintdolch aus Tultewitz, Burgenlandkreis

Xandra Dalidowski, Sergey Sitnikov, Marina Eguíluz Valentini, Christian-Heinrich Wunderlich, Harald Meller und Jan-Heinrich Bunnefeld

Summary

An Early Bronze Age Settlement Pit containing a Casting Mould for an Axehead and a Flint Dagger in Tultewitz, Burgenlandkreis district

During archaeological excavations in the area of the future road B 87n, a settlement area was documented near Tultewitz, Burgenlandkreis district, close to the Saale River. It has been used since the Early Neolithic period. In an apparently two-phase settlement pit (Feature 902), ceramics and stone artefacts were found alongside burnt clay and animal bones, including a flint dagger and half an Early Neolithic mace. Of particular importance are the first fragments in Central Germany of a stone mould for a blank of a flanged axe and another stone mould fragment possibly for a blank of a dagger or halberd blade. Based on the pottery, the contents of the pit can be dated primarily to the late Early Bronze Age (1775–1625 BC) but partially also to the Early Neolithic Linear Pottery Culture.

Keywords Early Bronze Age, axe, casting mould, flint dagger, stone tool

Zusammenfassung

Im Rahmen der archäologischen Ausgrabungen im Bereich der zukünftigen B 87n wurde bei Tultewitz, Burgenlandkreis, nahe der Saale ein Siedlungsareal dokumentiert, das seit dem Frühneolithikum genutzt worden ist. In einer anscheinend zweiphasigen Siedlungsgrube (Bef. 902) wurden neben Brandlehm und Tierknochen Keramikscherben und Steinartefakte gefunden, darunter ein Flintdolch und ein halber frühneolithischer Keulenkopf. Von besonderer Bedeutung sind erstmals in Mitteldeutschland das Fragment einer steinernen Gießform für einen Rohling eines Randleistenbeiles und ein weiteres steinernes Gießformfragment, eventuell für einen Rohling einer Dolch- oder Stabdolchklinge. Der Grubeninhalt kann anhand der Keramik vornehmlich in die jüngere Frühbronzezeit (1775–1625 v. Chr.), zum Teil auch in die frühneolithische Linienbandkeramikkultur datiert werden.

Schlagwörter Frühbronzezeit, Beil, Gießform, Flintdolch, Steinwerkzeug

Archäologie im Bereich der zukünftigen B 87n

In den Jahren 2019–2021 wurden im Zuge eines geplanten Straßenneubaus zwischen der heutigen B 87 westlich von Hassenhausen und der B 88 bei Janisroda, beide Burgenlandkreis, auf einer Strecke von 20 km insgesamt 25 Fundstellen archäologisch untersucht. Dabei konnten neue Erkenntnisse zur Besiedlung und Nutzung dieser Landschaft in den letzten 7500 Jahren gewonnen werden.

Erste Ackerbauern und Viehzüchter der Linienbandkeramikkultur ließen sich bereits Mitte des 6. Jts. v. Chr. vor allem in Gewässernähe in größerem Umfang nieder. Eine Fortsetzung der Besiedlung der Region wurde auch für das weitere Neolithikum und die Bronze- und Eisenzeit nachgewiesen. Für das Mittelalter liegen vergleichsweise wenige archäologische Hinterlassenschaften vor. Dies kann damit begründet werden, dass die Ansiedlungen größtenteils bis in heutige Zeit Bestand haben, wie die vielen alten, nahe beieinander liegenden Dörfer der Region demonstrieren. Militärische Aktivitäten zur Zeit der Napoleonischen Kriege 1806 und 1813 konnten vor allem in Form von Munition auf dem Schlachtfeld bei Hassenhausen und im Bereich der Durchzugswege der Heere sowie durch Soldatengräber im Bereich des Schlachtfeldes nachgewiesen werden.

Eine der wichtigsten Fundstellen des Großprojektes lag unmittelbar angrenzend an die heutige kleine Ortschaft Tultewitz, Burgenlandkreis. Heutzutage nicht in unmittelbarer Gewässernähe gelegen, befand sich die Fundstelle auf einer Hangterrasse des nach Westen bzw. Nordwesten zur knapp 1,5 km entfernten Saale abfallenden Geländes. Ausgeprägte Einschnitte in Form von Rinnen belegen eine zumindest temporäre Wasserführung und Entwässerung in die Saale. Auf ca. 1,5 ha wurden mehr als 1600 Befunde ausgegraben und dokumentiert, deren Großteil der Linienbandkeramikkultur zugeordnet werden kann (Abb. 1). Im südlichen Bereich der untersuchten Fläche wurden ebenso Befunde der Frühbronzezeit freigelegt.

Die Gesamtausdehnung des genutzten Siedlungsareals lässt sich nur schwer einschätzen, da die Untersuchungsflächen durch den Trassenkorridor beschränkt waren. Eine partielle Überlagerung der archäologischen Befunde durch die bestehende Ortschaft Tultewitz ist jedoch aus dem Grabungsplan abzuleiten.

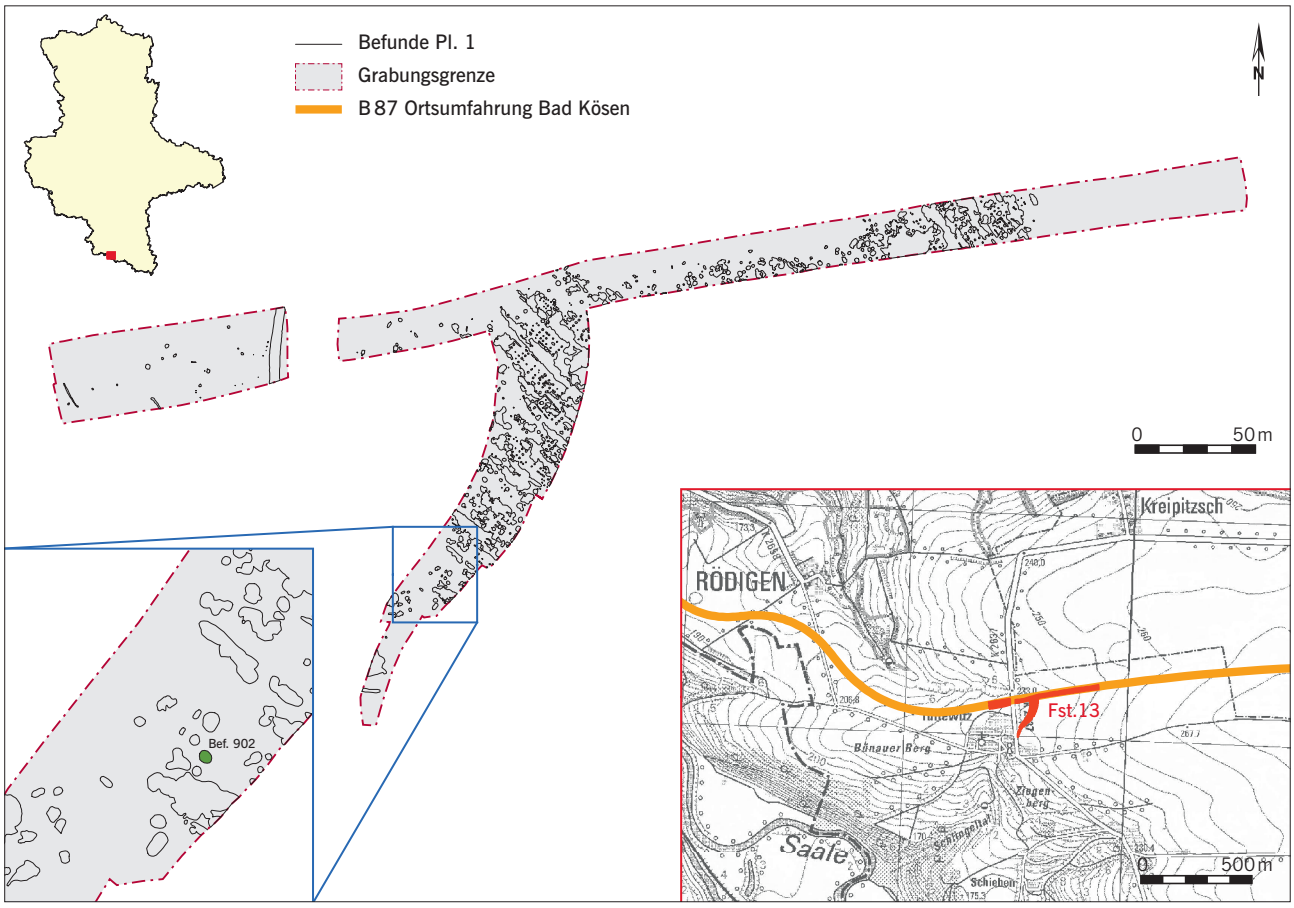


Abb. 1 Fundstelle Tultewitz, Bad Kösen, Stadt Naumburg, Burgenlandkreis, mit markiertem Bef. 902.

Fig. 1 *Excavation plan of the site at Tultewitz, Bad Kösen, town of Naumburg, Burgenlandkreis district, with the marked Feature 902.*

Die Siedlungsgrube Bef. 902

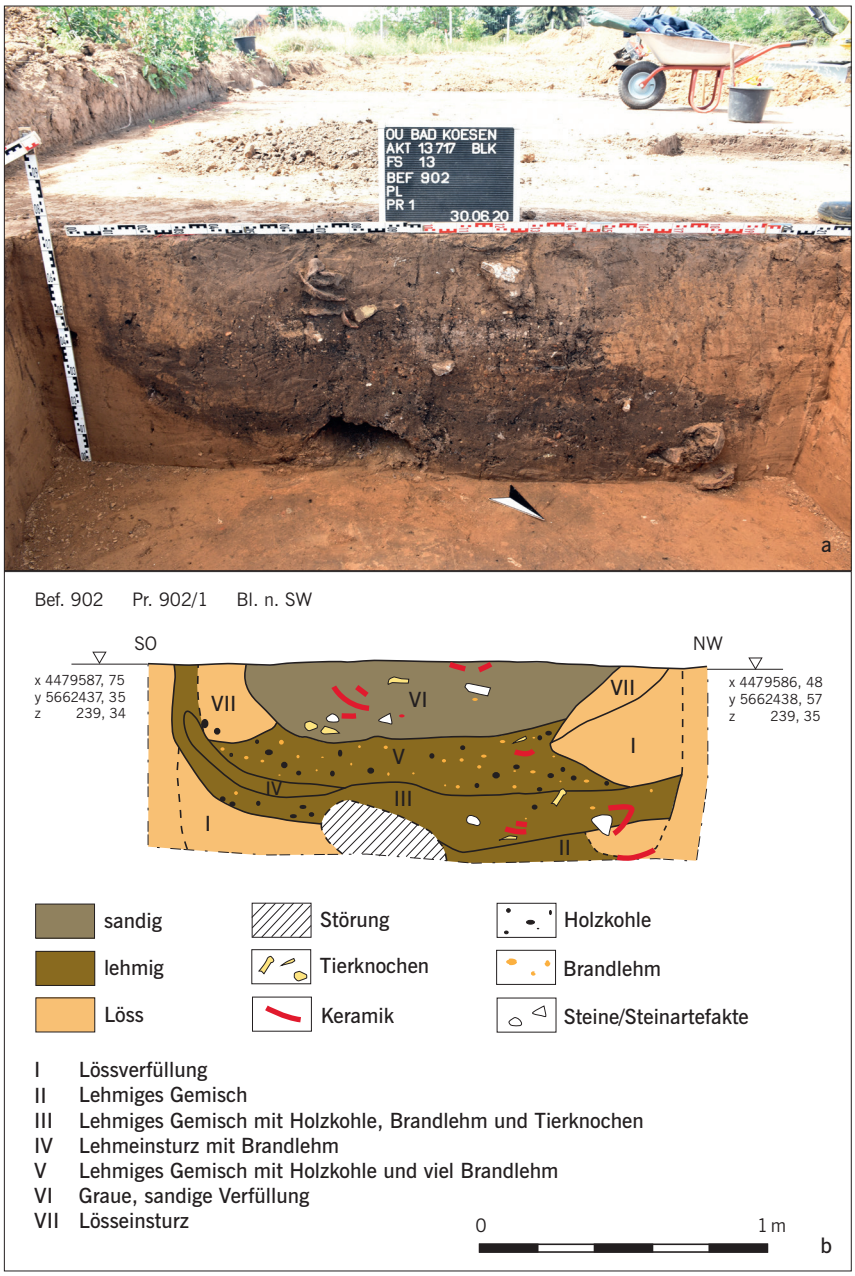
Bef. 902, eine leicht ovale, NW–SO-ausgerichtete dunkelbraune Verfärbung mit einer Länge von 1,57 m und einer Breite von 1,37 m, hob sich in keiner Weise von den benachbarten Gruben ab (Abb. 2). Wie die anderen Befunde lag sie im gelblich-ockerfarbenen, beinahe homogenen Löss und war von dem Anstehenden deutlich abgegrenzt. Das SO–NW angelegte Profil zeigte im oberen Bereich eine muldenförmige Grube, die in eine weitere, eher kesselförmige Grube mit massiven seitlichen Lösseinstürzen eingelassen war (Abb. 3). Diese Beobachtung wurde nicht nur durch eine eindeutige Abgrenzung beider Befunde zueinander, sondern auch durch eine unterschiedliche Verfüllung untermauert.

Abb. 2 Tultewitz, Burgenlandkreis. Planum von Bef. 902 (links).

Fig. 2 *Tultewitz, Burgernlandkreis district. Horizon of Feature 902 (left).*

Abb. 3a–b Tultewitz. Südost-Nordwest-Profil von Bef. 902. a Foto; b Zeichnung.

Fig. 3a–b *Tultewitz. South-east-north-west section of Feature 902. a Photograph; b drawing.*



Der gräuliche, schluffige Inhalt der oberen Grube kontrastierte mit dem bräunlichen, dunkleren und durch Lösseinwurf marmorierten Material der unteren, ursprünglichen Grube.

Die Anlage des Profils erwies sich aufgrund des Fundmaterials als kompliziert und aufwendig. Dieses bestand vor allem aus zahlreichen Keramikscherben, zerbrochenen Steinartefakten, Brandlehm und Tierknochen. Die folgenden Funde stammen wohl aus der oberen, jüngeren Grube.

Im obersten Teil der Verfüllung wurde ein kleiner Pfriem aus Bronze von 2,7 cm Länge geborgen, dessen mittlerer Teil leicht verbreitert ist (Abb. 4d).

Eine fragmentarische Gießform aus feinkörnigem Sandstein weist einen konkaven, durch Schleifen hergestellten Einzug von 6 mm Tiefe und 22–28 mm Breite auf, der den mittleren Teil des Körpers eines Randleistenbeiles repräsentiert (Abb. 4a; 5a–b). Unklar ist, ob es sich um eine einteilige offene Form handelte, ähnlich wie für die Herstellung des Beilrohlings von Freiroda, Burgenlandkreis (siehe Beitrag Bunnefeld u. a. in diesem Band), oder ob beim Guss eine Deckplatte oder sogar eine zweite passgenaue Formhälfte das Negativ abdeckte. Beide Seiten sind stark abgeschliffen und abgerundet, um ein regelmäßiges Profil zu erhalten. Der Bereich um das Negativ wurde geglättet. Hinweise auf thermische Veränderungen, wie Farbveränderung und Degradation der Gesteinsmatrix, sind im Inneren des Negativs sichtbar. Die Seiten der Gießform wurden offenbar anfänglich durch Abschläge in Form gebracht. Die Rückseite der Form und eine Seite bewahren noch die natürliche flache Oberfläche der ursprünglichen Sandsteinplatte. Die Randleisten sind in der Form nicht angelegt und wurden am Gussstück sicherlich nach dem Guss durch Schmieden herausgearbeitet (siehe Beiträge Bunnefeld u. a. und Michael u. a. in diesem Band).

Etwas sorgfältiger hergestellt wurde eine zweite Gießform aus feinkörnigem Sandstein (Abb. 4b; 5c–d). Alle

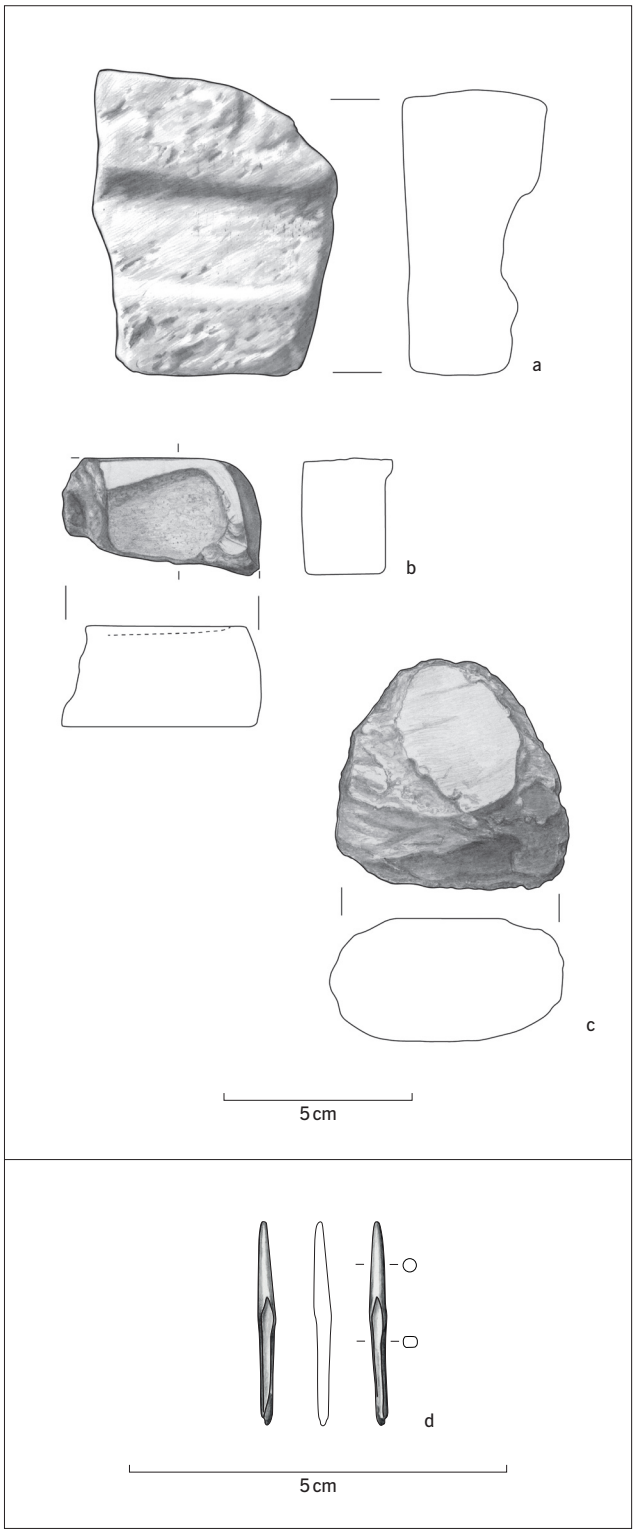


Abb. 4a–d Tultewitz. a Fragment einer Gießform für einen Beilrohling aus Sandstein; b Fragment einer Gießform, möglicherweise für einen Rohling einer Stabdolch- oder Dolchklinge aus Sandstein; c Fragment einer möglichen Abdeckung für eine Gießform aus Sandstein; d Bronzepfriem.

Fig. 4a–d *Tultewitz. a Fragment of a casting mould for an axe blank, made from sandstone; b Fragment of a mould, possibly for the blank of a halberd or dagger blade, made from sandstone; c possible fragment of the cover of a mould, made from sandstone; d bronze awl.*

passiven Seiten weisen eine sehr regelmäßige und glatte Oberfläche mit einer abgerundeten Ecke auf. Durch Schleifen wurde ein gut definiertes Negativ von geringer Tiefe herausgearbeitet, das für den Guss eines Rohlings für eine Stabdolch- oder – angesichts der Zeitstellung in der jüngeren Frühbronzezeit – eher Dolchklinge geeignet gewesen sein könnte[1]. Auch hier ist anzunehmen, dass zumindest eine Deckplatte existierte. Das Fragment weist keine Anzeichen einer thermischen Veränderung auf, wobei solche Spuren in dem verlorenen Teil des Negativs vorhanden gewesen sein könnten. Der mittlere Teil ist etwas rauer und nicht so sorgfältig poliert wie der Rest der Seiten.

Eine mögliche Deckplatte für eine Gießform wurde durch feines Abschleifen an den Seiten eines Sandsteins hergestellt (Abb. 4c), um die gewünschte Form und Abmessung zu erhalten, und anschließend auf der Vorder- und Rückseite poliert. Die Seite, die mit der Gießform in Berührung kommen würde, wurde stärker geschliffen, sodass eine ebene Oberfläche entstand. Der größte Teil dieser Seite ist verloren gegangen. Ob die kleine Deckplatte mit einer der beiden Gießformen in Verbindung steht, bleibt unklar.

Der Flintdolch, dem die Spitze fehlt, kann dem Typ V nach E. Lomborg zugeordnet werden, der sich durch ein verbreitertes Griffende und einen spitzovalen Griffquerschnitt auszeichnet (Abb. 6a; Lomborg 1973, 58–61). Allerdings liegt die größte Blattbreite hier nicht nahe des Griffs. Die Datierung in das Spätneolithikum C nach Lomborg (entspricht Late Neolithic II nach Vandkilde 1996) passt zur Zeitstellung der ebenfalls in der Grube gefundenen Keramik (Lomborg 1973, 69).

Neben dem Fischschwanzdolch wurde eine Hälfte eines polierten Keulenkopfes aus Gabbro oder einem ähnlichen Gestein entdeckt; sicherlich ein Altstück aus der Linienbandkeramikkultur, das die bronzezeitlichen Menschen auf dem alten Siedlungsplatz gefunden und sekundär genutzt haben (Abb. 6b). Die Bruchstelle liegt im Bereich des leicht konischen Schaftloches (vgl. Biermann 2011; Biermann 2024). Mit den Bruchkanten wurde auf ein hartes Material geschlagen. Die mit flachen Schlagspuren und Kratzern übersäte gerundete Seite wurde als Hammerstein vielleicht zur Flintbearbeitung genutzt.

Ein Sandstein mit bearbeiteter flacher Oberfläche ist im Umriss unregelmäßig trapezförmig (Abb. 7). Wahrscheinlich diente er als Ambossstein bei der bipolaren Zerlegung von Flint, worauf viele flache Schlagspuren im Zentrum der Vorderseite hindeuten, oder für andere kurzzeitige Aktivitäten, da das Gestein wenig widerstandsfähig ist.

An keinem der Steinartefakte wurden metallische Spuren entdeckt, die auf eine Verwendung bei der Metallbearbeitung hindeuten könnten.

Der überwiegende Teil der Siedlungskeramik gehört in die nachklassische Aunjetitzer Kultur (Taf. 1–4; Stufe AK 4; Schwarz 2021, 177–201)[2]. Es handelt sich sowohl um grobkeramische Vorratsgefäße mit Schlickrauung, einzelnen Fingertupfenverzierungen und verschiedenen Handhaben bzw.

1 Vgl. zur Gestalt entsprechender Rohlinge: Küßner/Wechler 2019, 463 Taf. 1 Nr. 11/101-52; 466 Taf. 4 Nr. 11/101-11.

2 Wir danken R. Schwarz, LDA Halle, für die Diskussion der Keramik.

Abb. 5a–d Tultewitz. a–b Fragment einer Gießform für einen Beilrohling aus Sandstein; c–d Fragment einer Gießform, möglicherweise für einen Rohling einer Stabdolch- oder Dolchklinge aus Sandstein.

Fig. 5a–d *Tultewitz. a–b Fragment of a casting mould for an axe blank, made from sandstone; c–d fragment of a mould, possibly for the blank of a halberd or dagger blade, made from sandstone.*

Ösenhenkeln als auch um Scherben unterschiedlicher kleinerer Gefäße, die zum Teil durch Besenstrich oder Textilrauung verziert sind. Für die Datierung in AK 4 spricht auch das Auftreten von kurz ausbiegenden (Taf. 2,4; 3,1.3–4), kurzen und verdickten (Taf. 1,15; 3,2.6.9.17; 4,4), trichterförmigen (Taf. 2,5), ausgestellten trichterförmigen (Taf. 4,5), sichel-

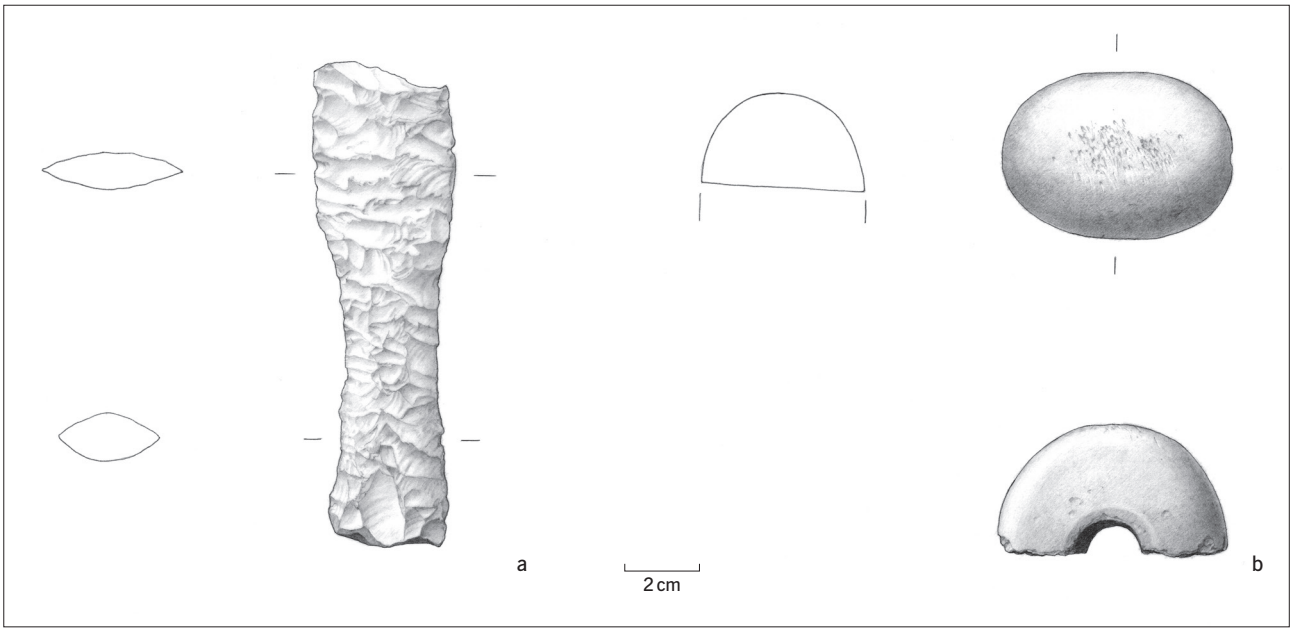


Abb. 6a–b Tultewitz. Steingeräte. a Flintdolch; b halber Keulenkopf.

Fig. 6a–b *Tultewitz. Stone implements. a Flint dagger; b half of a macehead.*

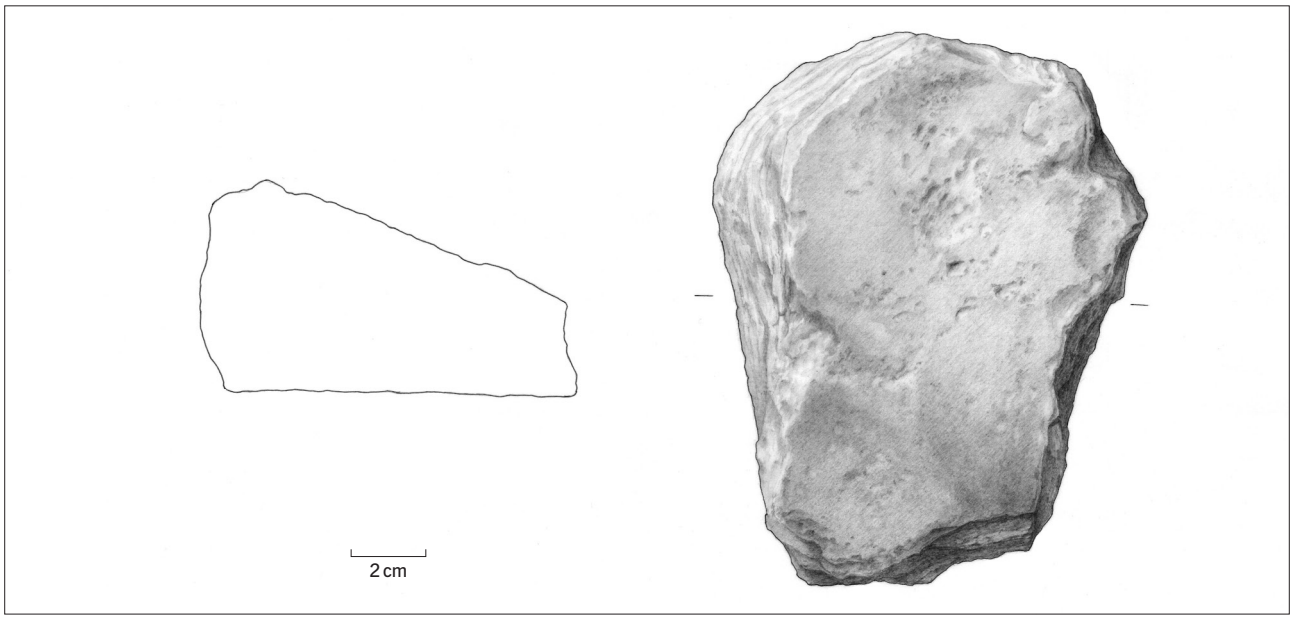


Abb. 7 Tultewitz. Ambossstein.

Fig. 7 *Tultewitz. Stone anvil.*

förmigen (Taf. 3,7) und c-förmigen (Taf. 4,1) Rändern. Die besterhaltenen Gefäße aus dem Befund sind eine einfache Schale (Taf. 4,3) und ein etwa trichterförmiger Schöpfer mit randständigem Ösenhenkel (Taf. 4,6). Besonders bemerkenswert sind einige Scherben mit Textilrauung als Verzierung, wie sie ähnlich aus Großörner, Lkr. Mansfeld-Südharz, vorliegt (Schwarz 2021, 190 Abb. 124 b).

In der Grube fanden sich außerdem Silexwerkzeuge und -abschläge und Keramik der Linienbandkeramikkultur, deren Position nicht dokumentiert ist, sowie in den unteren Schichten gebrannter Lehm vom Wandverputz und Tierknochen. Auch zwei menschliche Zähne, einer davon durchbohrt, sind darunter (Taf. 1,1). Die genaue Datierung dieser Funde ist nicht gesichert.

Ebenso unsicher ist die Datierung von zwei zusammen gefundenen Hammersteinen aus Quarzit. Beide weisen Spuren intensiver Nutzung auf, einschließlich Schläge auf die zersplitterten Kanten. Der lange Gebrauch und die umfangreichen Spuren auf verschiedenen Seiten der Werkzeuge deuten darauf hin, dass sie zum Hämmern, z. B. bei der Aufrauhung von Mahlsteinen, verwendet wurden. Ein weiterer Hammerstein aus Gneis, dessen Datierung ebenfalls nicht bekannt ist, weist ähnliche Spuren auf, aber in geringerer Intensität. Alle drei Gegenstände zeigen Spuren einer natürlichen Oberflächenveränderung durch Wassertransport, was darauf hindeutet, dass es sich um Findlinge handelt, die aus sekundären Ablagerungen in der Umgebung stammen.

Die Siedlungsgrube Bef. 902 ist ein bemerkenswerter Befund, der erstmals in Mitteldeutschland Gießformen aus Stein für ein Beil und möglicherweise einen Klingenrohling und zusätzlich Steinwerkzeuge sowie einen Flintdolch enthielt. Besonders wichtig ist, dass der frühbronzezeitliche Inhalt der Grube über die Keramik eindeutig in die nachklassische Aunjetitzer Kultur (1775–1625 v. Chr.) datiert werden kann.

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Abbildungsnachweis

1 X. Dalidowski, Kartengrundlage: DTK25 © GeoBasis-DE/LVermGeo LSA, 2013, 010213
2 S. Sitnikov
3 S. Sitnikov; b digitalisiert von M. Wiegmann, LDA
4 a J. Spengler, Halle (Saale); b–d J. Filipp, Bad Bibra
5 a–b J. Lipták, München; c–d A. Hörentrup, LDA
6 a–b T. Gellscheid, Halle (Saale)
7 T. Gellscheid, Halle (Saale)

Taf. 1–4 J. Spengler, Halle (Saale); Tafelmontage M. Wiegmann, LDA

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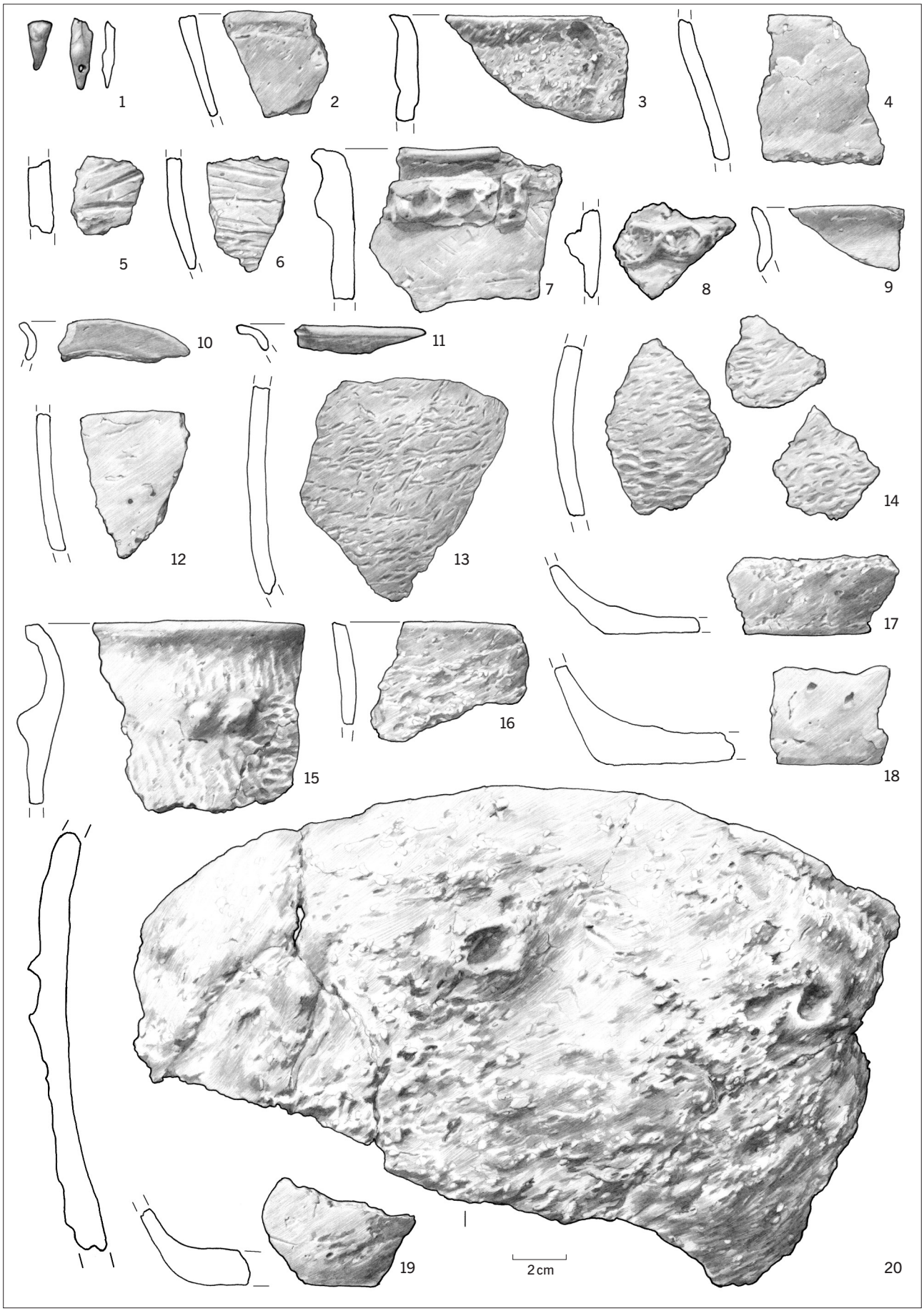
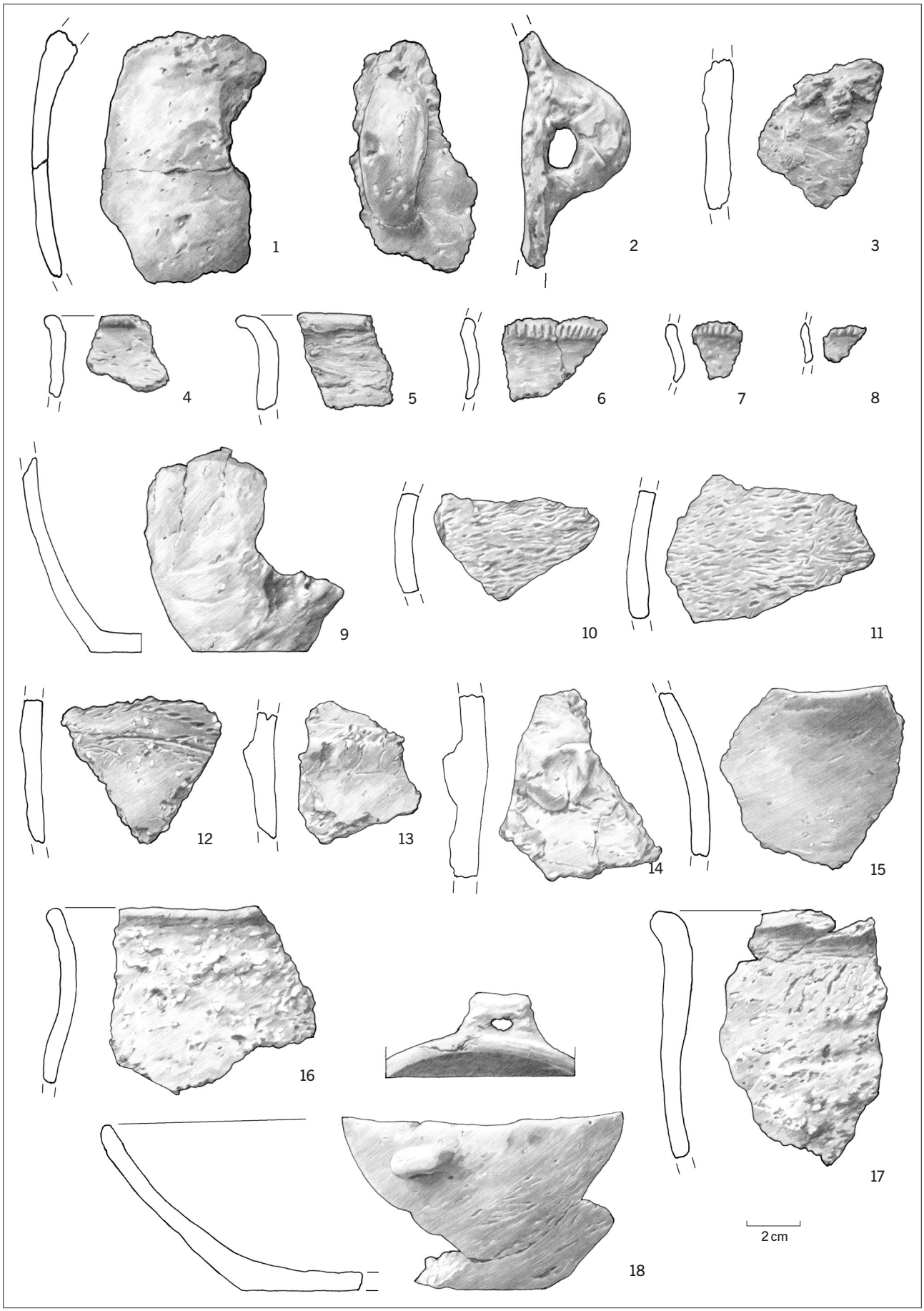
Tafel 1



Taf. 1 Tultewitz, Bad Kösen, Stadt Naumburg, Burgenlandkreis. Auswahl der Keramik und die Menschenzähne (1).

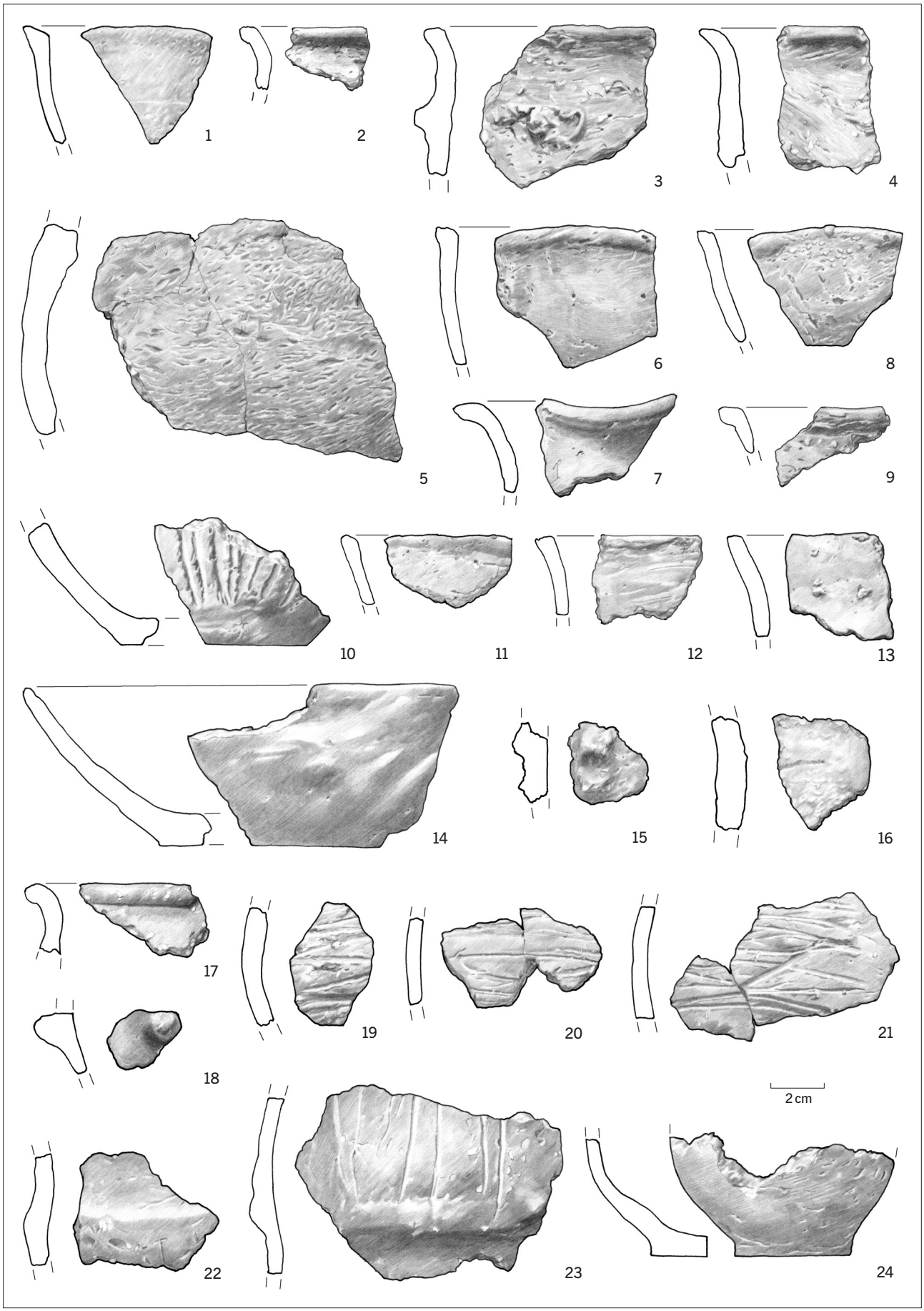
Pl. 1 *Tultewitz, Bad Kösen, town of Naumburg, Burgenlandkreis district. Pottery selection and the human teeth (1).*



Taf. 2 Tultewitz, Burgenlandkreis. Auswahl der Keramik.

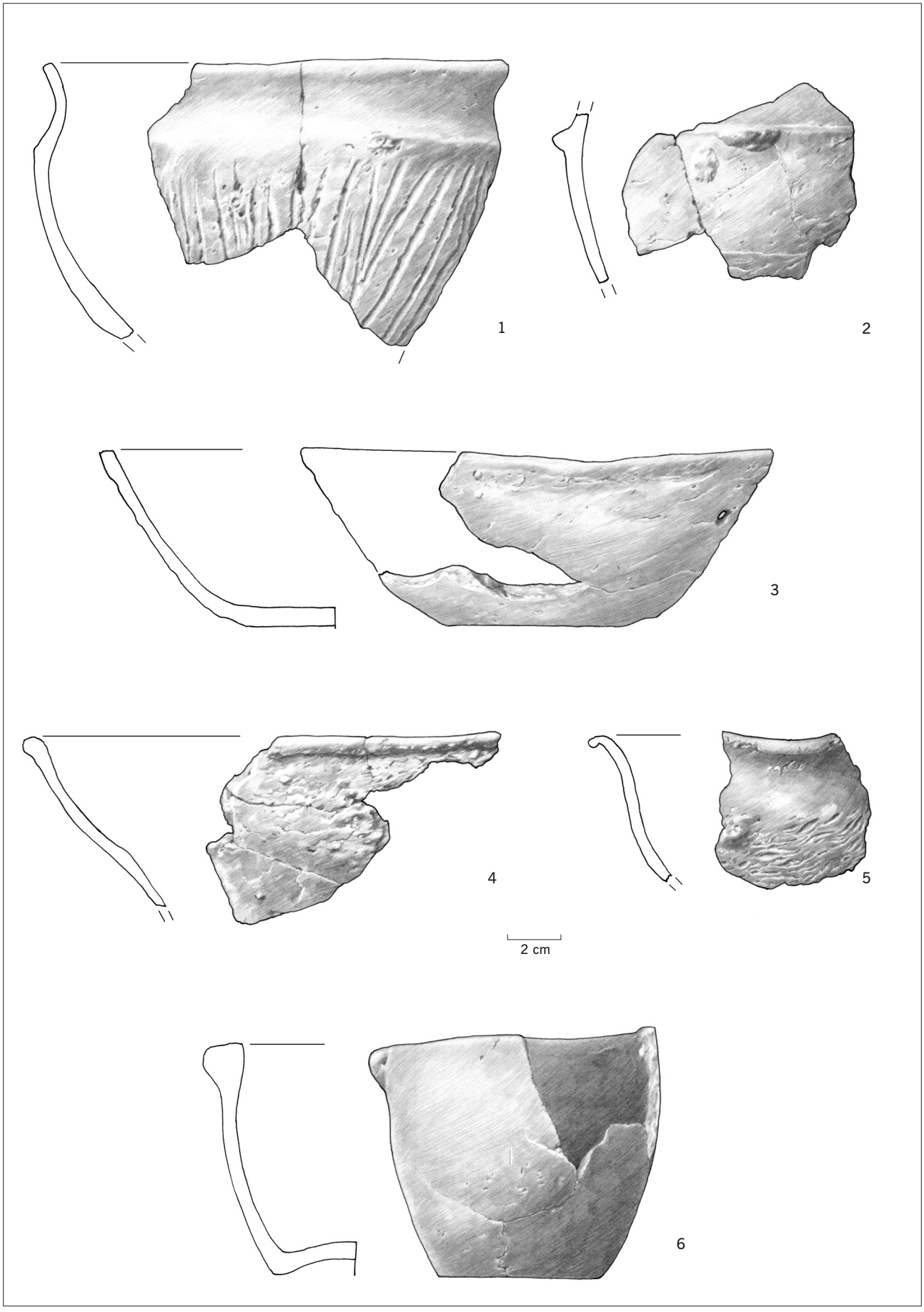
Pl. 2 *Tultewitz, Burgenlandkreis district. Pottery selection.*

Tafel 3



Taf. 3 Tultewitz, Burgenlandkreis. Auswahl der Keramik.

Pl. 3 *Tultewitz, Burgenlandkreis district. Pottery selection.*



Taf. 4 Tultewitz, Burgenlandkreis. Auswahl der Keramik.

Pl. 4 *Tultewitz, Burgenlandkreis district. Pottery selection.*

New approaches to the classification, chronology, and production of Iberian Bronze Age flat and flanged axes

Marcello Peres, Roberto Risch, and Eni Soriano

Zusammenfassung

Neue Ansätze zur Klassifizierung, Chronologie und Herstellung von Flach- und Randleistenbeilen der Iberischen Bronzezeit

Ein noch immer kaum verstandener Aspekt der prähistorischen Metallurgie ist die relativ späte Einführung von Gussformen aus Ton und Stein, die den Beginn der Serienproduktion von Metallobjekten markieren. Seit der zweiten Hälfte des 4. und dem 3. Jt. werden Gussformen häufig verwendet, um einen speziellen geschäfteten Axttyp in Osteuropa und der zirkumpontischen Zone herzustellen. Einige dieser Äxte stammen aus sogenannten Metallurgengräbern, bei denen es sich um Männergräber mit weiteren Werkzeugen zur Metallbearbeitung und häufig recht außergewöhnlichen Beigaben handelt. Zudem zeigt die Darstellung dieser Äxte in der Hand von Soldaten, Offizieren und Herrschern auf Steinstelen und Wanddekorationen mesopotamischer Paläste, dass diese in Gussformen gefertigten Äxte als Spezialwaffen verwendet wurden und eine zentrale Rolle bei der Bildung der ersten Armeen sowie bei der frühen Staatsbildung spielten.

Obwohl eine außergewöhnlich hohe Anzahl an bronzezeitlich steinernen Gussformen zur Herstellung von Beilklingen in den letzten Jahrzehnten auf der Iberischen Halbinsel entdeckt wurde, sind diese bisher nicht nach chronotypologischen und ökonomischen Gesichtspunkten untersucht worden. Die Analyse der Verbindung zwischen Gussmatrizen und Metallbeilen ermöglicht nicht nur deren genauere Datierung, sondern auch die Identifizierung der metallurgischen Herstellungszentren und der Austauschnetzwerke. Um diese Aspekte zu thematisieren, wurde eine Datenbank mit allen bisher publizierten Gussformen für Beile (n = 87) und einer beträchtlichen Anzahl von metallenen Flach- und Randleistenbeilen (n = 367) aus dem früh- und spätbronzezeitlichen Iberien (ca. 2200–1250 v. Chr.) erstellt. Diese enthält Material von 270 Fundplätzen aus allen Regionen der Iberischen Halbinsel sowie der Balearen. Unsere erste Auswertung konzentrierte sich auf die Morphometrie der Beile, um 1) mit statistischer Signifikanz taxonomische Typen zu ermitteln, um 2) die Chronologie dieser Taxa zu bestimmen und um schließlich 3) die existierenden Beziehungen zwischen Gussformen, Metallbeilen und ihren Ausgangsmaterialen (arsenhaltiges Kupfer im Gegensatz zu Zinnbronzen) aufzudecken. Die wichtigsten Ergebnisse lassen sich wie folgt zusammenfassen:

- *Es wurden 12 taxonomische Beiltypen bestimmt, die nicht alle mittels Gussform hergestellt wurden.*
- *Es bestehen enge Beziehungen zwischen einigen taxonomischen Typen, den räumlichen und zeitlichen Verbreitungen sowie deren chemischen Signaturen.*

Summary

A still ill-understood issue in Prehistoric metallurgy is the relatively late introduction of clay and stone moulds, which mark the beginning of the serial production of metals. Since the second half of the 4th and throughout the 3rd millennia, moulds were widely used to produce a specific type of hafted axe in in the Circum-Pontic region as well as in Eastern Europe. Some of them were placed in so-called metallurgist graves: male burials with other metalworking tools and, often, with exceptional grave goods. Moreover, the representation of these axes held by soldiers, officers, and rulers on stone stele and on wall decorations of Mesopotamian palaces reveals the use of these mould-made axes as specialised weapons and their central role in the making of the first armies and in early state formation.

Although an exceptional number of Bronze Age stone moulds for casting axeheads have been found during the last decades in the Iberian Peninsula, their matrices have not been analysed from a chrono-typological and economic perspective. The study of the relation of casting matrices with metal axes not only allows to refine the dating of both but also to identify the metallurgical centres and exchange networks. To address these issues, a database has been prepared including all axe moulds published so far (n = 87) and a significant number of metal flat and flanged axes (n = 367) from Early to Late Bronze Age Iberia (c. 2200–1250 BC). It includes materials from 270 archaeological sites from all Iberian peninsular regions as well as the Balearic Islands. Our first analysis has focused on axe morphometry in order to 1) obtain taxonomic types with statistical significance, 2) define the chronology of these taxa, and 3) reveal the relations existing between moulds, metal axes, and their raw materials (arsenical copper as opposed to tin bronzes). Major results can be summarised as follows:

- *12 taxonomic types of axes were determined, not all of which were produced using moulds.*
- *Close relations were established between some taxonomic types, spatial and temporal distributions, and chemical signatures.*
- *The spatial distribution of moulds suggests the development of clearly differentiated metal production centres in the Iberian Peninsula.*
- *The majority of moulds produced only two taxonomic axe types, both of which were related to El Argar, thereby reinforcing their interpretation as weapons.*
- *The presence of some of these axes and moulds outside the El Argar territory reveal the long-distance circulation and political/military interactions of El Argar with other regions.*

- *Die räumliche Verbreitung der Gussformen weist auf die Entwicklung klar unterscheidbarer Zentren der Metallproduktion auf der Iberischen Halbinsel hin.*
- *Aus der Mehrzahl der Gussformen wurden nur zwei taxonomische Beiltypen hergestellt, die beide mit der El-Argar-Kultur in Zusammenhang stehen, was ihre Interpretation als Waffen untermauert.*
- *Das Vorhandensein einiger dieser Beile und Gussformen außerhalb des Gebiets der El-Argar-Kultur belegt den weiträumigen Umlauf und die politischen/militärischen Interaktionen der El-Argar-Kultur mit anderen Regionen.*

Damit werden die Ergebnisse einer neuartigen multidimensionalen Methodik vorgestellt, die es uns ermöglicht, ein tieferes Verständnis für die Organisation und den sozialen Wert der Metallbeilproduktion und -verbreitung während der Bronzezeit in Südwesteuropa zu gewinnen.

Schlagwörter Bronzezeitliche Metallurgie, Gussformen, Beilherstellung, Zirkulation von Metallen, Iberische Halbinsel

In sum, the results of a novel multidimensional methodology will be presented, which allows us to gain a deeper understanding of the organisation and social value of metal axe production and circulation during the Bronze Age of South-Western Europe.

Keywords Bronze Age metallurgy, casting moulds, axe production, metal circulation, Iberian Peninsula

Introduction

Axes were one of the first and the principal objects made with moulds during the Copper and Bronze Ages in Asia and Europe. The technological and economic advantage of solid moulds made of stone or fired clay is the possibility to start bulk production of standardised objects. While metals with similar size and weight are an important step towards the emergence of exchange values and early forms of money, casting in solid moulds makes it possible to supply larger populations and/or territories from one productive centre, if the necessary raw materials are available.

The earliest known moulds were found in Tepe Ghabristan, Qazvin province (Iran), and date to the early 4th millennium BC (Majidzadeh 1979; Fazeli Nashli et al. 2013). They were made of fired clay and served to produce axes and ingots, while other objects, such as daggers and knifes, continued to be produced in single-use casts or, simply, by forging metal bars. Since the second half of the 4th and throughout the 3rd millennia, clay moulds were widely used to produce a specific type of hafted axe in east-central Europe as well as in the Circum-Pontic area (Boroffka 2009; Szeverényi 2013; Batora 2006; cf. Hansen in this volume). Some of these moulds were placed in so-called metallurgist graves. These are, with very few exceptions, male burials, and the exceptional wealth of the accompanying grave goods placed in many of them provides insight into the social and economic importance of these metalworking tools. Moreover, the representation of these axes held by soldiers, officers, and rulers on stone stele, such as the Stele of the Vultures, on wall decorations of Mesopotamian palaces, such as Mari, or on exceptional portable objects, such as the well-known »standard of Ur«, reveals the importance of these mould-made axes as specialised weapons of the first armies in early state formation (Parrot 2006; Risch 2020).

Although stone moulds seem to have been introduced in the Iberian Peninsula at the transition from the Copper to the Bronze Ages, c. 2300–2100 BC (Lull et al. 2015c), the first well-contextualised axe casts from sites such as Orpesa La Vella (Castelló), Minferri (Lleida), and possibly Loma del Lomo (Guadalajara; Equip Minferri 1997; Olària/Gusi 2014; Valiente Malla 2001) can be dated to around 1900–1800 BC. By 1700 BC at the latest, axe moulds were also used at the Atlantic side of Iberia, as the example from Fraga dos Corvos, in northern Portugal, confirms (Senna-Martinez/Luís 2016, 119). This points towards a quick and widespread adoption of the new technology in large – but by far not all – parts of Iberian Peninsula and raises the question concerning the social and political motivations behind such a decisive productive change. The possible relation between the bulk production of axes and the emergence of armies has recently been discussed for the classical phase of the Únětice period (c. 1975–1750 BC) of Central Europe (Meller 2019) and might offer a further explanation for the appearance of moulds in the Western Mediterranean, where the El Argar complex was developing similar forms of political and economic organisation. The presence of a specific group of male burials distinguished by axes – and daggers – in the El Argar territory, which are particularly abundant at the name-giving site itself (Siret/Siret 1890; Lull et al. 2018; Bonora Soriano 2021; cf. Bonora Soriano in this volume), may confirm the rise of specialised warrior unions.

In the wider context of the Bronze Age economic take-off, the possible rise of organised forms of violence and even war, as observed in the Tollense Valley in northern Germany (Krüger et al. 2020), and the emergence of state or state-like societies based on the regular extraction of surplus value over larger territories in the Aegean, Central Europe and South-Eastern Iberia (Delgado Raack/Risch 2015; Risch et al. 2021), the aim of the present study is to explore, for the first

time from a classificatory, chronological, and spatial perspective, the nearly one hundred stone moulds known to be from the Iberian Peninsula.

Although a large number and variety of axes and casting moulds are known from Bronze Age Iberia, these artefacts have largely been overlooked since L. Monteagudo (1977) published the large catalogue of all Iberian copper and bronze axes known five decades ago. While the corpus of metal axes has not changed in significant numbers, the number of moulds has multiplied by a factor of 7.3 – from 12 to 87 – and even perhaps by a factor of 8, if the known 96 axe-casting matrices are also considered. Such an increase in archaeological evidence should allow, in the first place, a significant improvement in the dating of axes, which usually are casual finds or come from isolated hoards, whereas moulds are often found in more or less well-defined settlement contexts. Moreover, the morphometrical classification and spatial distribution of casting matrices and axes provides valuable information on the economic organisation of metal production and circulation. Finally, the chemical composition and the lead isotope relations of the metals used to produce axes allows researchers to refine their classification and thus shed further light on the relation between the production, circulation, and use of axes. At that stage, we can start discussing the exchange networks functioning in Iberia during the Bronze Age based on solid archaeological evidence.

The present study marks the start of a long-term research program along the lines just described. It will mainly focus on a new classification taxonomy of the Iberian flat axes[1] and on the dating of the different productions. After presenting the rationale behind the proposed classification, the following questions will be addressed:

1. What variety of axes were produced in the Iberian Peninsula during the Bronze Age?
2. What was the time frame of axe production and circulation?
3. Which axes could have been produced with stone moulds?
4. What is the proportion between moulds and axes of different shapes?

Materials: Stone moulds and copper and bronze axes

So far, 87 stone moulds with 96 matrices related to axe production are known from Bronze Age Iberia (Fig. 1)[2]. These include three unpublished moulds from Cabezo Redondo (Alicante; Fig. 1, M062, M063, and M066) and three more from Santaella (Córdoba), Castellet de la Plana, and Castell d'Almassora, both in Castelló (Fig. 2). Complete information concerning the shape and size of the axes cast in these matrices is available in 48 cases. The single site with by far the largest number of moulds is the El Argar settlement of Peñalosa (Jaén) located in the rich mining district of Linares-La Carolina (Contreras Cortés 2000). However, most of the 17 published matrices served to cast axe-shaped ingots rather than axe blanks or preforms (Fig. 1, M025 and M026). Their matrices, according to the published drawings and photos, are more irregular and deeper than the other matrices in Iberia, which closely resemble finished axes. The large number and exceptionality of moulds used to produce ingots underlines, among other evidence (number of crucibles, volume of slags, etc.), the scale of the metallurgical exploitation in Peñalosa and the Rambla del Rumblar in general.

Excluding broken moulds and the tools from Peñalosa, 41 matrices provide the morphological and metrical information necessary to establish a classification of the casted axe blanks. These shapes have been compared statistically to finished axes. As it is unnecessary for the established aims to reliably describe all Early, Middle, and Late Bronze Age axes of the Iberian Peninsula, only axes fulfilling the following criteria were included in the data base:

1. All axes coming from hoards and with published drawings and metrical dimensions.
2. All axes for which chemical analysis as well as drawings and metrical dimensions are available.
3. All axes published in regional studies of Bronze Age metallurgy[3].
4. A sample of the remaining axes with published drawings and metrical dimensions, giving priority to those best contextualised and with ^{14}C dates.

It was also established that all modern-day provinces should be represented in the data base in order to be able to model the spatial patterns of axe circulation without large empty »islands«. In total, 367 axes fulfilled the established criteria, 364 of which offer full metrical and morphological information. Of these, 16 are flanged axes with ridges along the body. They are the earliest type of flanged axes known in Iberia, dated between the Middle to Late Bronze Age. It was decided to include them because of their temporal synchrony with

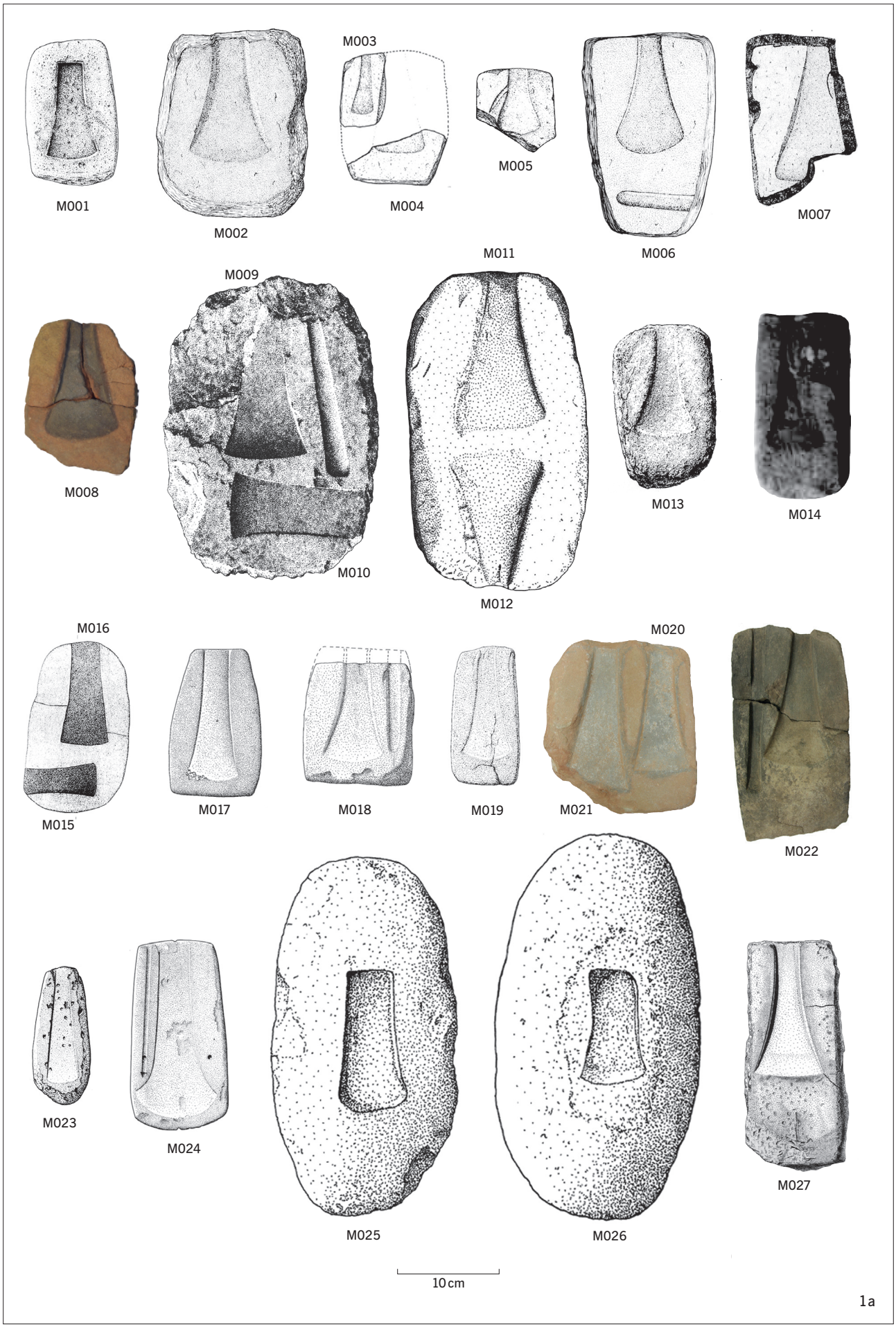
Fig. 1a–c (following pages) Axe matrices included in this study with their respective serial number. The moulds at the bottom (M034–M038, M056, M057, M069, M070, M072, and M074) are axe-shaped ingot matrices from Peñalosa (Jaén), not included in this study. Note that some matrices come from the same mould. See Annex 1 for references of drawings and photos and the exact sites.

Abb. 1a–c (folgende Seiten) *Beilmatrizen, die Teil dieser Untersuchung waren, und ihre jeweiligen Seriennummern. Bei den unteren Formen (M034–M038, M056, M057, M069, M070, M072 und M074) handelt es sich um beilförmige Barrenmatrizen aus Peñalosa (Jaén), die nicht in dieser Untersuchung einbezogen wurden. Man beachte, dass einige der Matrizen von demselben Formmodell stammen. Siehe Annex 1 für bildliche Darstellungen in der Literatur und die genauen Fundorte.*

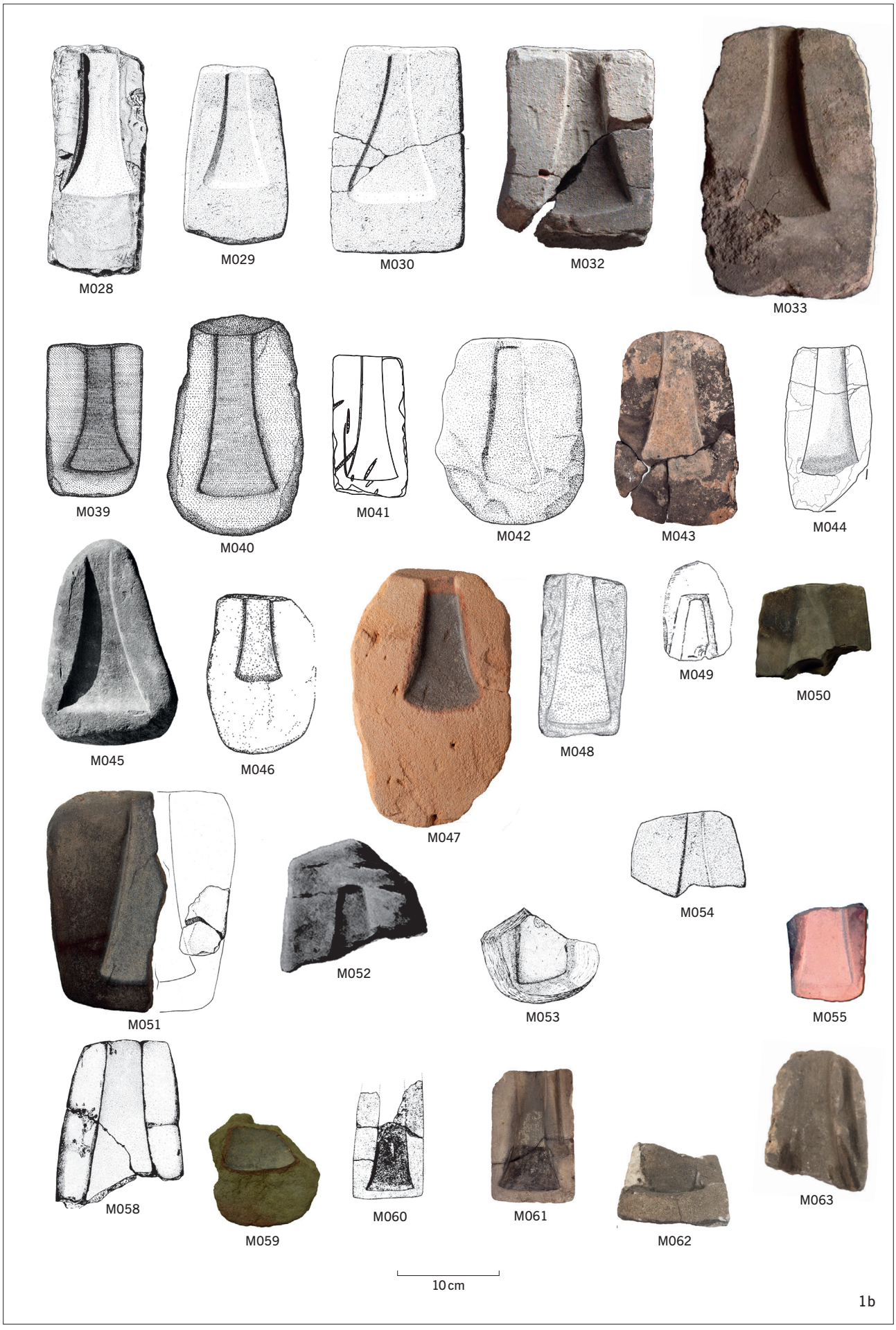
1 Throughout the text the term *axe* refers to *flat axe*, unless otherwise stated.

2 Apart from later moulds, some doubtful or unclear ones have been excluded from the study, such as: »M« structure of El Argar (Monteagudo 1977, no. 389A), El Castellet (Simón García 1998, 168), Cerro de las Viñas (Ayala 1991, 385), Cerro de la Virgen (Delgado Raack 2008, 387), and Monachil (Rauret 1976).

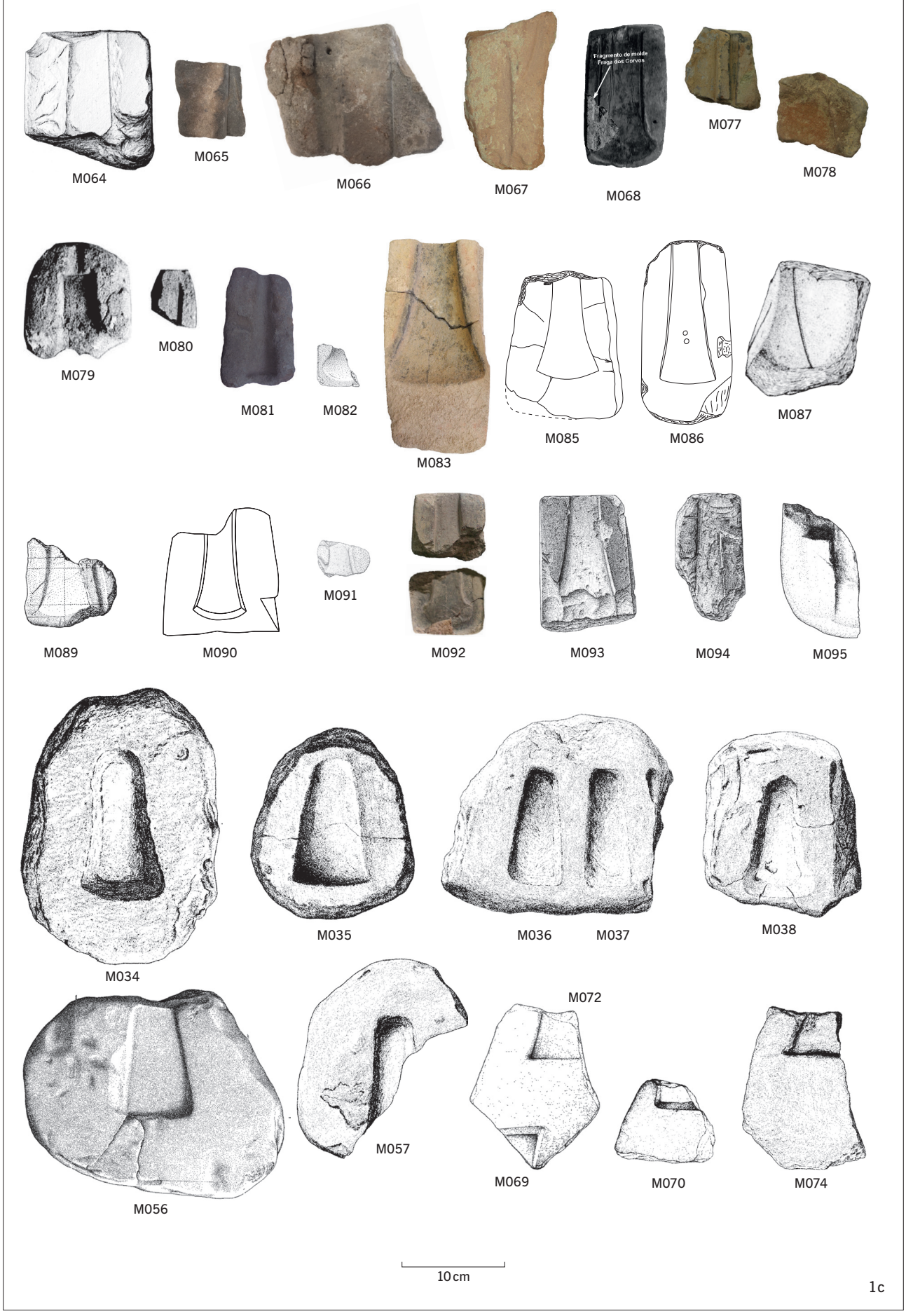
3 Schubart 1975; Montero Ruiz 1991; Comendador Rey 1997; Simón 1998; Díaz-Andreu García/Montero Ruiz 1998; Blas Cortina 1999; Delibes de Castro et al. 1999a; Delibes de Castro et al. 1999b; Hunt Ortiz 2003; Rodríguez de la Esperanza 2005; Herrán Martínez 2008; Soriano 2013.


M001
M002
M003
M004
M005
M006
M007
M008
M009
M010
M011
M012
M013
M014
M015
M016
M017
M018
M019
M020
M021
M022
M023
M024
M025
M026
M027
10 cm

1a


M028
M029
M030
M032
M033
M039
M040
M041
M042
M043
M044
M045
M046
M047
M048
M049
M050
M051
M052
M053
M054
M055
M058
M059
M060
M061
M062
M063
10 cm

1b


M064
M065
M066
M067
Fragmento de molde
Fraga dos Corvos
M068
M077
M078
M079
M080
M081
M082
M083
M085
M086
M087
M089
M090
M091
M092
M093
M094
M095
M034
M035
M036
M037
M038
M056
M057
M072
M069
M070
M074
10 cm

1c

Fig. 2a–c Unpublished axe moulds included in this study. a M044, Santaella (Santaella, Córdoba); b M086, Castellet de la Plana (Castelló de la Plana, Castelló); c M085, Castell d'Almassora (Almassora, Castelló). See Annex 1 for the references to museums.

Abb. 2a–c *Bisher unpublizierte, in der Untersuchung einbezogene Gussformen. a M044 Santaella (Santaella, Córdoba); b M086 Castellet de la Plana (Castelló de la Plana, Castelló); c M085 Castell d'Almassora (Almassora, Castelló). Siehe Annex 1 für Namen der beherbergenden Museen.*

the flat axes and because they seem to have been cast in the same moulds and then hammered to create the flanges. The almost total absence of flanged axe moulds in Iberia and the rest of Europe supports this statement (Rodríguez de la Esperanza 2005, 122; Soriano 2013, 100).

The geographical distribution for the 463 axes and axe matrices recorded so far is shown in Fig. 3[4]. All information is summarised in Annex 1. Consecutive numbers have been given according to the type of object: flat axes (H), flanged axes (HR), and moulds (M). In relation to moulds, they are followed by a letter in parentheses if they have more than one axe matrix: e.g., Cuesta del Negro (A), Cuesta del Negro (B), etc. A number indicates whether there is more than one mould in the same site: e.g., El Argar 1, El Argar 2, etc.

Method: Classification strategy

The proposed classification strategy of Iberian axes follows a taxonomic rather than a typological approach. A series

4 We divided the Iberian Peninsula into ten regions defined by both geographical integrity and current administrative borders: Balearic Islands (BI), Eastern or Levante (E), Ebro Valley (EV), Northern (N), North-Eastern (NE), North Meseta (NM), North-Western (NW), South-Eastern (SE), South Meseta (SM) and South-Western (SW). The only objective is to facilitate the presentation of data.

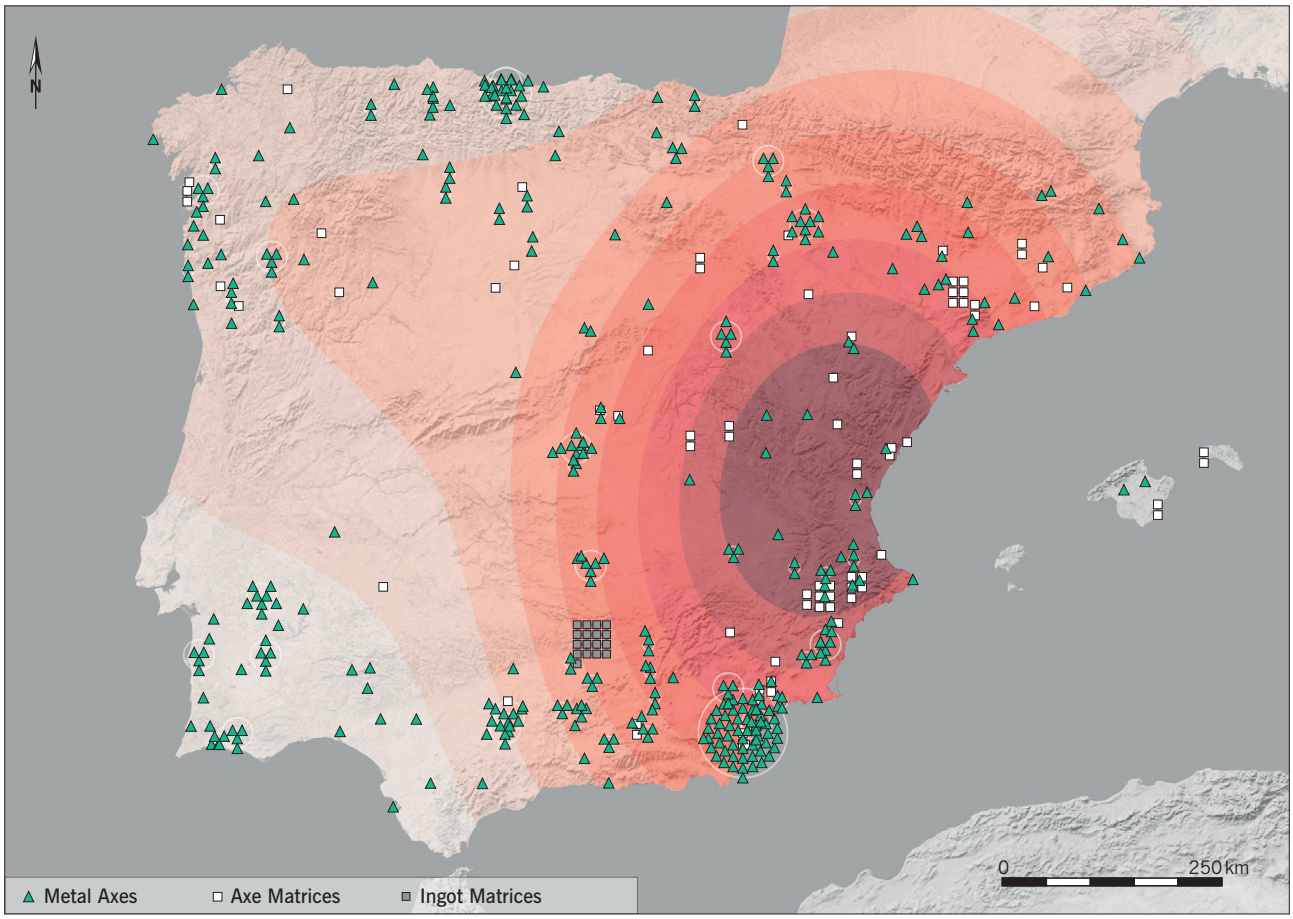


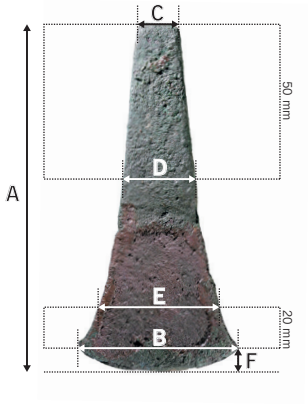
Fig. 3 Map of the Iberian Peninsula with the distribution of 96 axe matrices and 367 metal axes examined in the study, including axe-shaped ingot matrices from Peñalosa (Jaén). The background heatmap represents the concentration of axe matrices, from 0 (white) to > 38 quantiles (dark red).

Abb. 3 *Karte der Iberischen Halbinsel mit der Verteilung von 96 Beilmatrizen und 367 in der Studie untersuchten Metallbeile, einschließlich der beilförmigen Barrenmatrizen aus Peñalosa (Jaén). Die Heatmap im Hintergrund stellt die Konzentration der Beilmatrizen dar, von 0 (weiß) bis > 38 Quantilen (dunkelrot).*

of epistemological and methodological differences distinguish both ways of ordering things, events, or relations. The most important one is that a typology is conceptually established and then focuses on specimens, whereas a taxonomy emerges inductively from the empirical analysis of existing entities (Bailey 1994). Conceptual types are usually defined monothetically, implying that all artefacts of one type share the same properties and, hence, are conceptionally identical. It follows that typologies, at least when they are systematic, either do not establish a hierarchy between classificatory criteria or can only follow one classificatory logic. Instead, taxa are polythetic classifications. Morphometrical descriptors allow one to identify groups of artefacts which share enough traits as to differentiate them from other groups, but not necessarily all. Taxonomies are much more flexible than typologies and can identify different discriminating traits for different groups, depending on the variability of the analysed universe and not on preestablished notions. In biology, for example, phylogenetic observations modify purely phenotypical classifications or alter the order of the classificatory criteria. Objects can be grouped into a different class based only on one observed parameter.

A taxonomic approach is required to classify metal axes because it cannot be assumed that all workshops followed the same production and design criteria in the whole of the Iberian Peninsula over more than 1000 years of Bronze Age development. Some traits or parameters might have been relevant in certain areas and periods, while others were not, or not to the same extent. Social, economic, or technical constrains, such as their use as tools or as weapons, the hafting technology, the availability of raw materials, etc., conditioned axe production and, consequently, their design in different ways among the diverse Bronze Age communities of the Iberian Peninsula. The process of taxonomic classification should not only classify the objects but help to unveil which dimensions where relevant to each taxon.

Any classification of metal tools and weapons also has to take into account that their original shape and dimensions could change during their use-life due to repeated forging and sharpening. These tasks are indispensable to maintain the use value of the objects. More specifically, their active bevels forming cutting edges would be modified by use and maintenance activities, while their body and passive sides remained less exposed to such modifications. As a well-functioning axe requires that the axehead remains hafted in a wooden shaft, it can be expected that large parts of the body remained unmodified after their initial forging. Impressions of wooden shafts are often visible on the oxidised surface of the axes and offer an indication

Descriptor	Dimension	Definition	Representation
A	Length	Maximal length between the butt and the cutting edge of the axe	
B	Blade width	Maximal length of the blade	
C	Butt width	Maximal length of the butt	
D	Axe width at 50 mm from butt	Body width at 50 mm distance from the butt	
E	Axe width at 20 mm	Body width at 20 mm from the straight line defining variable B	
F	Cutting edge convexity	Distance between the cutting edge and the straight line defining variable B	
G	Weight	Weight of the axe in g. Unfortunately, this measurement is often missing in the publications.	
H	Flange shape	Straight (ST) or Concave (CC) shapes are distinguished visually	
Angle 1 (An1)	Shaft angle	Angle of the flanges between C and D	= DEGREES(ATAN((D-C)/2/50))
Angle 2 (An2)	Body angle	Angle of the flanges between C and E	= DEGREES(ATAN((E-C)/2/(A-F-20)))
Angle 3 (An3)	Blade angle	Angle of the blade between B and E	= DEGREES(ATAN((B-E)/2/20))
Ratio 1 (R1)	Slenderness	Relation between the length and the overall width of the axe	= (B+C)/A
Ratio 2 (R2)	Symmetry	Relation between length and butt	= C/A

Tab. 1 Metric and morphological variables and angles used to classify metal axes and their graphic or mathematical representation.

Tab. 1 *Metrische und morphologische Variablen und Winkel zur Klassifizierung von Metallbeilen und ihre grafische bzw. mathematische Darstellung.*

of the original shape of the handle. Micro and macroscopic observations (10–40X) have allowed us to identify traces on many artefacts coming from El Argar burials (Siret/Siret 1890, tombs 48, 69, 116, 307, 400, 434, 572, 50, 639, 654, 768), indicating that the hafts covered the body of the axes over more than 50 mm of its length from the butt, independently of the dimensions of the tools (Tab. 1). Instead, as expected and indicated by experimental archaeology (Kienlin/Ottaway 1998; Roberts/Ottaway 2003; Soriano/Gutiérrez 2009), use and resharpening traces were mostly identified on the edge of the axes. This technological difference implies that any classification of axeheads needs to follow a hierarchical logic which lends greater weight to the dimensions related to the initial casting and forging processes than to those affected by resharpening. Given the importance of technology, working processes, and use-life on different parts of the axehead, a landmark-based approach is more convenient than an outline-based one.

Step 1: Establishing the classification landmarks and dimensions

All axe matrices and axes were defined according to six basic metrical dimensions defined by nine landmarks (Tab. 1, A–F). The maximal length and width (Tab. 1, A and B), as well as the butt width (Tab. 1, C) are usually noted in archaeology or can be derived from published drawings[5]. Unfortunately, weight (Tab. 1, G) has only been measured among one third (138/367) of the axes, although it offers a direct quantification of the amount of metal used to produce an axe. The convexity of the cutting edge (Tab. 1, F) is also not measured regularly but can be retrieved from existing drawings. Given the importance of the axe body in the taxonomic classification, two additional measurements of the width between flanges at fixed distances from the butt and cutting edge were included in the system (Tab. 1, D and E).

The only qualitative morphological parameter considered in the classification process was the shape of the flanges, which can be concave, straight, and, very rarely in this chronology, convex (Tab. 1, H). These shapes can be regarded as a further result of casting and forging processes.

Given the functional importance of a solid hafting of the axeheads, the width descriptors C, D, and E were used to establish the angle of divergence of the axe flanges, which – combined with flange's shape (Tab. 1, H) – can be used as a representation of the geometry of the axe body (Tab. 1, An1 and An2). A third angle between widths E and B was calculated to define the opening angle of the cutting edge (Tab. 1, An3). Given that this part of an axe is likely to have been resharpened, it should have a lower weight in the classification.

The metrical descriptors allow us to establish indices between different measurements, e.g., the proportion between maximal width and length (B/A). After different

5 Only thickness was omitted from our classification. This dimension and its variability are too small to serve as a classificatory criteria. But, most of all, it is expected that axes loose thickness during the forging of the axe blanks and, hence, diverge from the depth of casting matrices.

	A	B	C	D	E	F	An1	An2	An3
A	1.000	*0.853*	*0.856*	*0.823*	*0.887*	0.698	-0.391	-0.246	0.094
B		1.000	*0.872*	*0.884*	*0.966*	*0.777*	-0.239	0.084	0.383
C			1.000	*0.967*	*0.907*	*0.711*	-0.442	-0.308	0.093
D				1.000	*0.931*	0.696	-0.198	-0.131	0.059
E					1.000	0.699	-0.211	0.051	0.132
F						1.000	-0.287	-0.091	0.470
An1							1.000	*0.720*	-0.152
An2								1.000	0.158
An3									1.000

Tab. 2 Correlation matrix between descriptors A–F and angles An1–3 (see Tab. 1). Flat and flanged axes, as well as casting matrices are considered. Highly significant correlations ($R^2 > 0.7$) appear in italics. Shapes where A-F-70 mm < 0 have been excluded, as in these exceptionally small matrices and axes (M003, M005, H006, H022, H192, H188) the landmarks of E lay closer to the butt than those of D.

***Tab. 2** Korrelationsmatrix zwischen den Deskriptoren A–F und den Winkeln An1–3 (vgl. Tab. 1). Einbezogen wurden Flach- und Randleistenbeile sowie Gussmatrizen. Hochsignifikante Korrelationen ($R^2 > 0,7$) sind kursiv dargestellt. Exemplare, bei denen A-F-70 mm < 0 gilt, wurden ausgenommen, da bei diesen ungewöhnlich kleinen Matrizen und Beilen (M003, M005, H006, H022, H192, H188) E näher am Nacken liegt als D.*

ratios were tested, the most discriminant criteria proved to be the relation between length (A) and the sum of the width of the butt and the cutting edge (B and C), and the relation between the length (A) and the butt alone (C). While the first can be understood as an index of the amount of metal used to produce an axe of a certain length, the second expresses the slenderness of the tool (Tab. 1, R1 and R2).

Once the classificatory criteria had been established, 96 complete and fragmented matrices and 367 axes were described accordingly. Nearly infinitely more dimensions can be measured, but it is unlikely that they would allow for a better, i.e., more discriminant, taxonomy, because the number of casting matrices is much more limited than the number of axes. Even approximate matches between the two are rare. As each artefact and matrix is unique, an increase in variables would result in a greater differentiation rather than in a clustering of the artefacts. As already noted, a taxonomy attempts to classify populations rather than individual objects.

Step 2: Determining relations between landmarks

The process of building an axe taxonomy started with different statistical approaches to determine the relation between the recorded landmarks as a necessary step towards grasping the underlying order of a universe or population.

In the first place, the correlation of all established dimensions and angles was calculated with correspondence analysis (Tab. 2). According to the resulting R-values, all metrical parameters are highly correlated, suggesting that size was the overall determining factor in axe production and their variability. In contrast, the angles of the flange (An1 and An2), which describe the profile of axe bodies, follow a very different trend (Tab. 2). Angle An1 even maintains negative correlation values with all sizes, implying that, in general, larger axes tend to have more parallel flanges than smaller ones. This is an unexpected result, as it implies that large, more rectangular shaped axes required disproportionately more metal than smaller ones, which spared raw materials by casting and forging more divergent flanges, resulting in trapezoidal or triangular shaped axes. On the contrary, the very negative R-value between the body angles An1 and An2 and the butt width C is a logical outcome, as wider butts will tend to result in rectangular body profiles, and vice versa.

Step 3: Determining the variability of axes

Principal Component Analysis (PCA) was used to identify the underlying structure of the morphometry of 327 peninsular axes and axe matrices. Axes larger than 180 mm in length were excluded from this test, as no moulds with matrices of such size are known from the Iberian Peninsula and most of these axes belong, rather surprisingly, to two already defined axe types: *Yunclillos* and *Asiego* (see below). Flanged axes were also excluded as their landmarks do not correspond to a cast either; the small axes or axe matrices M003, M005, H006, H022, H192, H188 were likewise excluded.

As can be expected from the previous correlation matrix (Tab. 2), only two clusters or factors are necessary to explain the morphometrical variability of Iberian axeheads. After several runs, the clearest pattern emerged when only dimensions A, B, C, D, and E and the angles A1 and A2 were included. As expected, the variability of all metrical distances is expressed by the PC1, which explains 58.6 % of the sample variability. By contrast, the angles are weighted in PC2, which expresses 28.2 % of the total variability (Tab. 3). In other words, axe size and the shape of the axe body are unrelated and can be expected to provide the main classificatory criteria. The remaining variability can be expressed in further factors, but their eigenvalues lay below 1 and, hence, are not significant.

The resulting PC1 was found to be highly correlated with weight (Fig. 4). This is an important observation, as the regression equation between both variables provides a useful way to infer the approximate weight of the axes where this variable is missing (c. 66 %), as the R^2 value provided ($R^2 = 0.86$) is significantly higher than in a regression between the length and weight of axes ($R^2 = 0.69$). The

weight of the flat axes up to 180 mm length varies between 45 and 870 g. The fact that a linear regression curve provides the highest R value implies that larger axes required proportionally more metal than smaller ones (Fig. 4), as is also suggested by the strong correlation of all dimensions *(supra)*.

The second factor of the PCA reveals that Iberian axes differ in the shape of their bodies and, more specifically, in the divergence of their flanges. As already mentioned, this feature is related to the hafting of the axes and resulted from their casting and initial forging. It follows that the main classificatory criteria of the axeheads need to be derived from angles 1 and 2 (Tab. 1). The correlation matrix and PCA (Tab. 2–3) also shows that these angles are negatively correlated with the width of the butt (C), implying that axes with narrow butts tend to present more divergent flanges, and vice versa. Consequently, the dimension of the axe butts can be expected to provide a further classificatory criterion.

	PC 1	PC 2
A	0.824	-0.128
B	0.903	0.277
C	0.917	-0.245
D	0.861	0.141
E	0.938	0.304
An1	-0.414	0.825
An2	0.15	0.962

	Magnitude	Variance proportion
Factor 1	4.127	0.590
Factor 2	1.873	0.268
Factor 3	0.634	0.091

Tab. 3 Unrotated factor scores of the main axe descriptors and their eigenvalues.

Tab. 3 *Unrotierte Faktorwerte der wichtigsten Beildeskriptoren und ihre Eigenwerte.*

Step 4: Defining the taxonomic criteria

Once the classificatory landmarks and the dimensions between them were defined and their underlying logic understood, it was possible to establish meaningful taxonomic criteria.

Criterion 1

The first, more general level of classification should take into account axe sizes, as their variability could be expressed by the first factor of the PCA. These values follow a more or less normal distribution around a mean value, suggesting that values are not clustered. However, if axeheads also larger than 180 mm are included, for which no casting moulds are known, two more concentrations of lengths become visible (Fig. 5). The first clusters around 170–200 mm and includes most of the axes already defined as *Asiego* or *Cabrales* (Harbison 1967; Blas Cortina 1999, 55). The second ranges from 220 to 310 mm in length and distinguishes the so called *Yunclillos* type axes (Ruiz-Taboada et al. 2019).

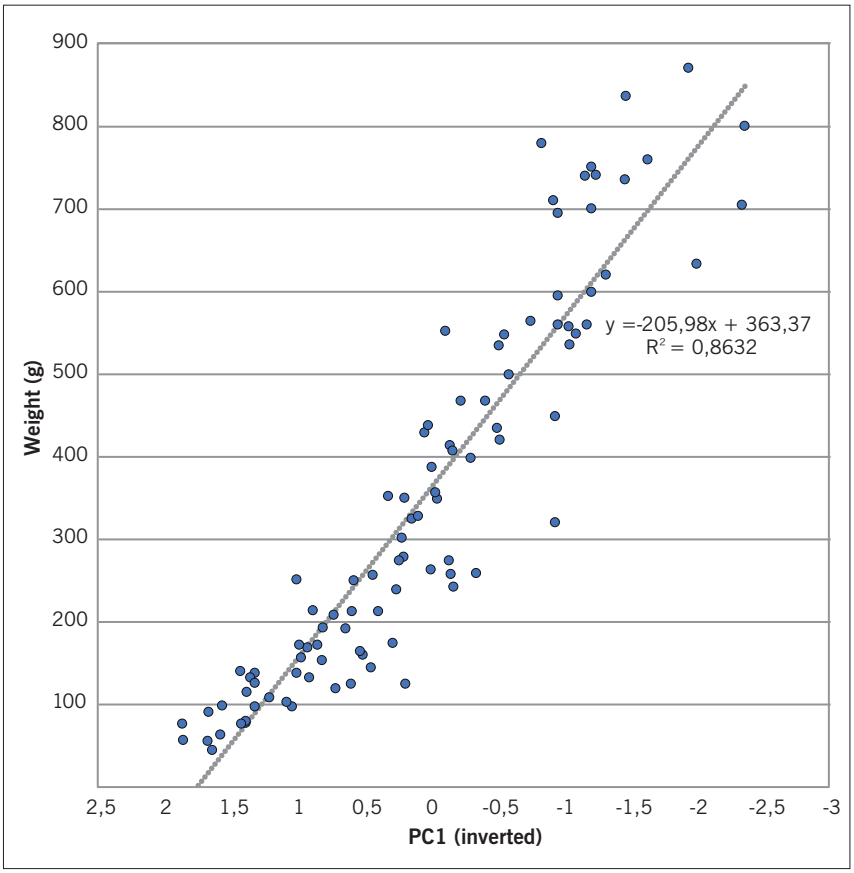


Fig. 4 Regression between unrotated PC1 and axe weight (g), measured in 96 cases.

Abb. 4 *Beziehung zwischen unrotiertem PC1 und dem in 96 Fällen gemessenen Beilgewicht (g).*

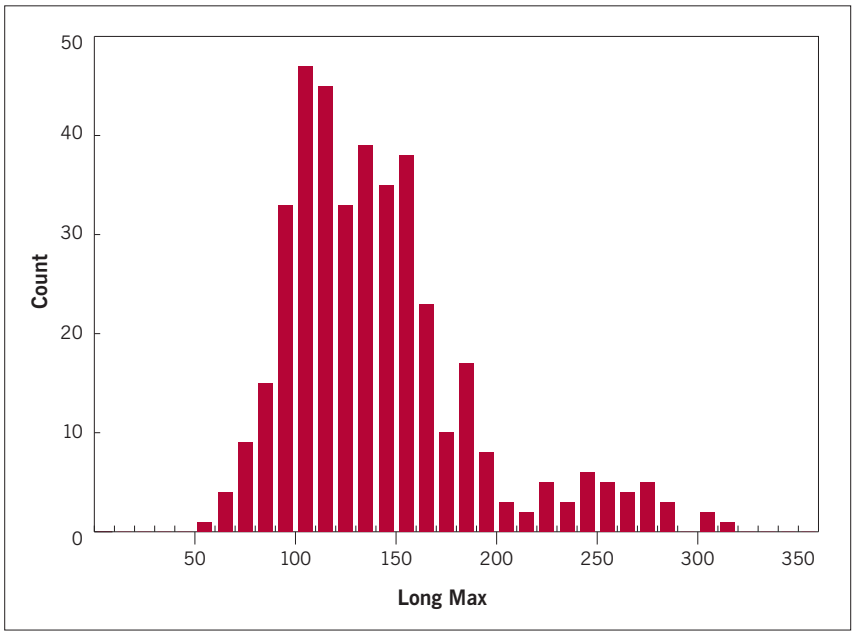


Fig. 5 Frequency distribution of the length of axeheads and matrices.

Abb. 5 *Häufigkeitsverteilung der Länge von Beilklingen und Matrizen.*

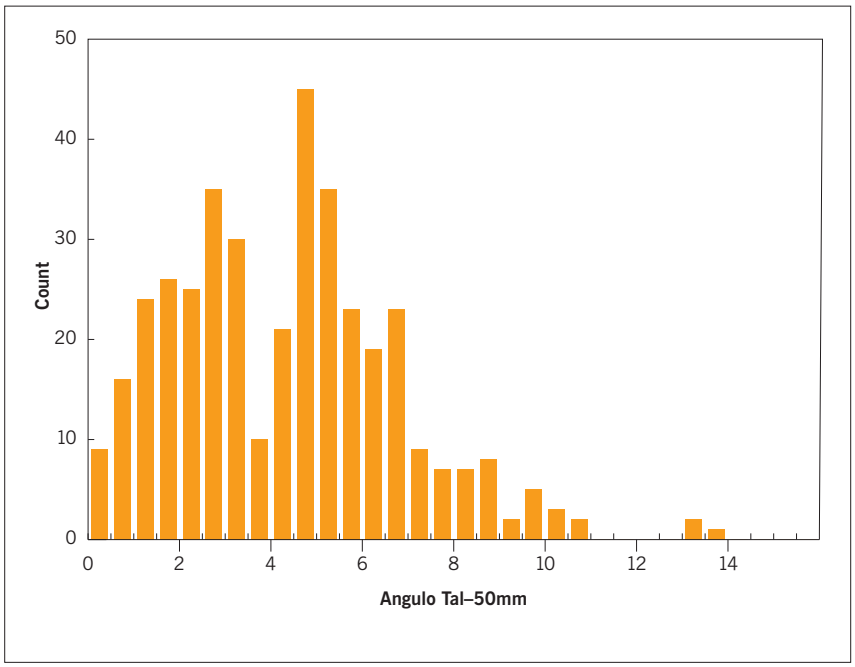


Fig. 6 Frequency distribution of angle An1 of axeheads and matrices.

Abb. 6 *Häufigkeitsverteilung des Winkels An1 der Beilklingen und Matrizen.*

Criterion 2

The second level of the taxonomy should derive from the angle or divergence of the axe's flanges. According to the PCA, axeheads below 180 mm in length should be classified mainly according to the shaft and body angles (Tab. 1, An1 and An2). The frequency distribution of the first suggests three clusters (Fig. 6). The thresholds appearing around 3.5° and 8° allow one to distinguish three main body profiles (Tab. 4).

Criterion 3

Given its close relation with the hafting device and its negative relation with the body divergency angles, the butt width (Tab. 1, C; 5) should be used as the third classificatory criteria. Again, three clusters can be proposed based on the frequency distribution.

Criterion 4

Although the ratios of symmetry and slenderness (Tab. 1, R1 and R2) cannot be included in the PCA (no dimension should be weighted more than once), they allow us to refine the classification of axe shapes. Both are highly correlated but cluster differently (Tab. 6–7) and allow a better classification of the axe bodies. The handling of an axe depends on the point of balance of the blade, where the weight is distributed equally to each side of the body. Very narrow shapes will have their balance point closer to the cutting edge. Wider axe bodies, however, will have their balance point towards the butt. The resulting kinetics and the

Tab. 4 Classification according to the shape of axe bodies based on the angle of flange divergence.

Tab. 4 *Klassifikation anhand der Gestalt der Seitenprofile der Beile.*

Code	Category	Definition
REC	Rectangular	An1 ≤ 3° U An2 ≤ 6°
TRA	Trapezoidal	An1 > 3° U An2 > 6°
TRI	Triangular	(An1 + An2)/2 > 8°

Tab. 5 Classification according to the axe butt width.

Tab. 5 *Klassifikation anhand der Nackenbreite.*

Code	Category	Definition
TE	Thin butts	≤ 33 mm
TM	Medium butts	> 33 mm U < 50 mm
TA	Wide butts	≥ 50 mm

Tab. 6 Axe classification according to the symmetry of the body.

Tab. 6 *Klassifikation anhand der Symmetrie der Beilklingen.*

Code	Category	Definition
SB	Low symmetry	C/A > 0.2; axes are wider in relation to their length
SA	High symmetry	C/A ≤ 0.2; this implies that the width of the butt is 1/5 or less of the total axe length.

Tab. 7 Axe classification according to the slenderness of the body.

Tab. 7 *Klassifikation anhand der Schlankheit der Beilklingen.*

Code	Category	Definition
EB	Low slenderness	(B+C)/A > 0.8
EN	Medium	(B+C)/A ≤ 0.8 U >0.6
EA	High slenderness	(B+C)/A ≤ 0.6

Tab. 8 Axe classification according to cutting edge divergence.

Tab. 8 *Klassifikation anhand des Winkels zum Schneidenende.*

Code	Category	Definition
F0	Unmodified cutting edge profile	A3-A2 < 3°
F1	Slightly diverging cutting edge	A3-A2 > 3° U A3 < 20°
F2	Open cutting edge	A3 ≥ 20°

impact strength can be expected to vary substantially according to the absolute weight and the weight balance of the tools.

Criterion 5

During the classification process it was noted that certain axes and matrices have protruding cutting edges, while in others the angles of the flanges (Tab. 1, An1 and An2) and of the cutting edges (An3) are very similar (Tab. 8). As already indicated, the protrusion or opening of the cutting edges is more prone to modifications by forging activities during the use-life of an axe than the other dimensions. We tried to overcome this difficulty, at least partially, by correcting the degree of divergence visually. Lateral extensions of the axe cutting edges, which are a characteristic trait of their resharpening through forging, were not taken into account and corrected manually.

Criterion 6

The classification of axeheads also considered whether the convex or straight shape of the axe flanges was a discriminant criterion, at least in some groups.

In sum, apart from their size, axes and their casting matrices were classified according to a maximum of six criteria that express the observed variability of nine metrical dimensions between landmarks, one qualitative observation, and two ratios between dimensions (Tab. 1). Potentially, this procedure would allow us to discriminate 324 different taxa. However, given that a polythetic and hierarchical strategy is used, few criteria are required to cluster the axes and matrices into mutually excluding groups. The proposed taxonomical approach allows us to classify all Iberian axes, except rare outliers which will either be excluded or considered *variants* of the main taxa.

Previous research has identified some monothetic types among the Iberian axes, such as the already mentioned Asiego and Yunclillos type axes. These subjectively defined types will be integrated into the present classification if they can be singled out also through taxonomic criteria.

Step 5: Confirmation of taxa through chemical analysis of the axes

An additional criterion of classification is provided by the chemical composition of the metals. Mainly, three labo-

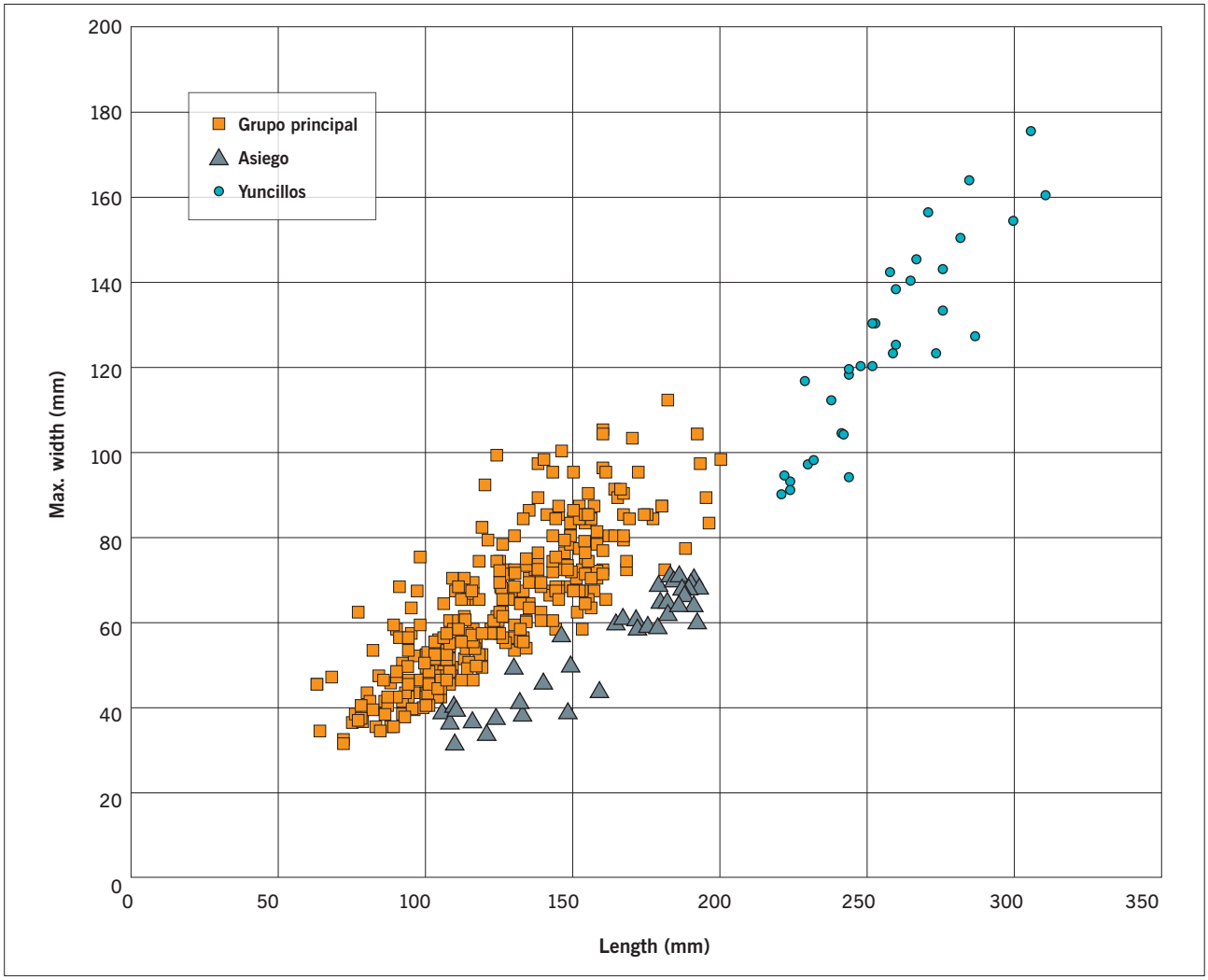


Fig. 7 Relation between length (Tab. 1A) and width (Tab. 1B) of all mould matrices and axes.

Abb. 7 *Beziehung zwischen Länge (Tab. 1A) und Breite (Tab. 1B) sämtlicher Matrizen und Beile.*

ratories and projects have carried out chemical analysis, though with variable precision and accuracy, of Iberian metals, including c. 50 % of the classified axes and traces of metal from three matrices of two axe moulds. The first series of analyses were carried out by the research program *Studien zu den Anfängen der Metallurgie* (SAM; Junghans et al. 1960; Junghans et al. 1968; Junghans et al. 1974). Their results can be regarded as reliable for a series of elements (Pernicka 1990; Pernicka 2014; Müller/Pernicka 2009). A small number of analyses has been carried out by the *British Museum* (BM) and fulfil common quality standards (Harrison/Craddock 1981). Another series of chemical data has been obtained by the *Proyecto Arqueometalurgia de la Península Ibérica* (PA) of the Spanish Research Council CSIC (Rovira Llorens et al. 1997). In this case, the amount of arsenic in the metals from the first of series AA and PA (up to analysis 10 000) has proven to be systematically lower than when measured with more precise methods, but the values can be corrected[6]. Subsequent analyses related to the same project do not need to be corrected thanks to the change of the equipment used (Rovira Llorens/Montero Ruiz 2018). More recently, a large set of axes from Northern Iberia (Asturias province) has been analysed and included in our research (Reguera-Galán et al. 2018)[7]. Although not all chemical data sets are comparable due to the different techniques and equipment used, technically significative amounts (> 0.5 %) of arsenic (As), tin (Sn), and lead (Pb) content were identified by all methods and allow us to distinguish four metal types:

1. Pure copper with less than < 0.5 % of As, Sn, or Pb
2. Arsenical copper with > 0.5 % of As
3. Tin bronze with > 1 % of Sn
4. Tin bronze with > 1 % Sn and > 0.5 % Pb.

6 The correction factor is 2.2356. We thank S. Rovira Llorens for providing this information.

7 Other sets of analysis have been excluded due to the technique used or to the few axes considered (Simón García 1998; Bottaini et al. 2012; Bashore Acero 2013; Senna-Martinez et al. 2013; Montero Fenollós et al. 2014).

These four metal types are related to technical and economic changes in metal production that tend to follow regional and chronological patterns which allow us to confirm the relation of taxa with productive centres and to refine the former.

Result 1: Axe classification according to length and width

A classification usually organises things from a more general to a more specific level. Metric dimensions were identified by PCA (see above) as the main source of variability of Iberian axes. The correlation between single dimensions (Tab. 1, A–F) showed that plotting length to its width already allowed us to distinguish four general clusters. A very distinct group coincides with axes commonly named the Yunclillos type (Fig. 7). Not only are they larger than all other axes (A > 200 mm), but they also show a very different relation between length and width. The correlation index between both variables is exceptionally high ($R^2 = 0.8$), suggesting that all are produced following the same notion of symmetry. Such a standardisation is surprising, especially considering that no moulds are known for Yunclillos axes. This makes a provenance of all artefacts from the same workshop or small group of workshops specialising in the production of highly standardised ingots likely.

A very different cluster is defined by axes of another well-known type, named after the metal deposit of Asiego in Asturias (Fig. 7). Metrically, they can be distinguished from the rest by having much narrower cutting edges in relation to the maximum length. The ratio between the two descriptors varies between > 0.26 and < 0.40 and distinguishes slender shapes. The correlation index is again high (R^2 0.82). However, their distribution along the regression line is not continuous, as in the case of the Yunclillos axes. An absence of artefacts of around 160 mm in length and 50–65 mm in width allows us to differentiate between Large and Small Asiego taxa. The first includes all tools from the well-known deposit of northern Spain (Reguera-Galán et al. 2018).

All other axes scatter widely between c. 60–180 mm in length and have wider cutting edges in comparison to their length or weight (Fig. 7). This mayor group, including 284 (69 %) of the 412 fully recorded Iberian axes and casting matrices, needs to be classified according to the remaining five criteria defining the shape of the axes.

Result 2: The axe taxa

Most moulds and axes, including conventional types, have been classified according to the proposed procedure. First, the axes already distinguished based on their metric descriptors are scrutinised. Next, we focus on the shape of the main group of axes. Finally, from the available chemical composition analyses, the type of metal is specified.

YUNCLILLOS: REC or TRA-TA-SB-F1

The Yunclillos taxon includes 35 axes, one of them being a variant, but no moulds (Fig. 8). These axes can be easily

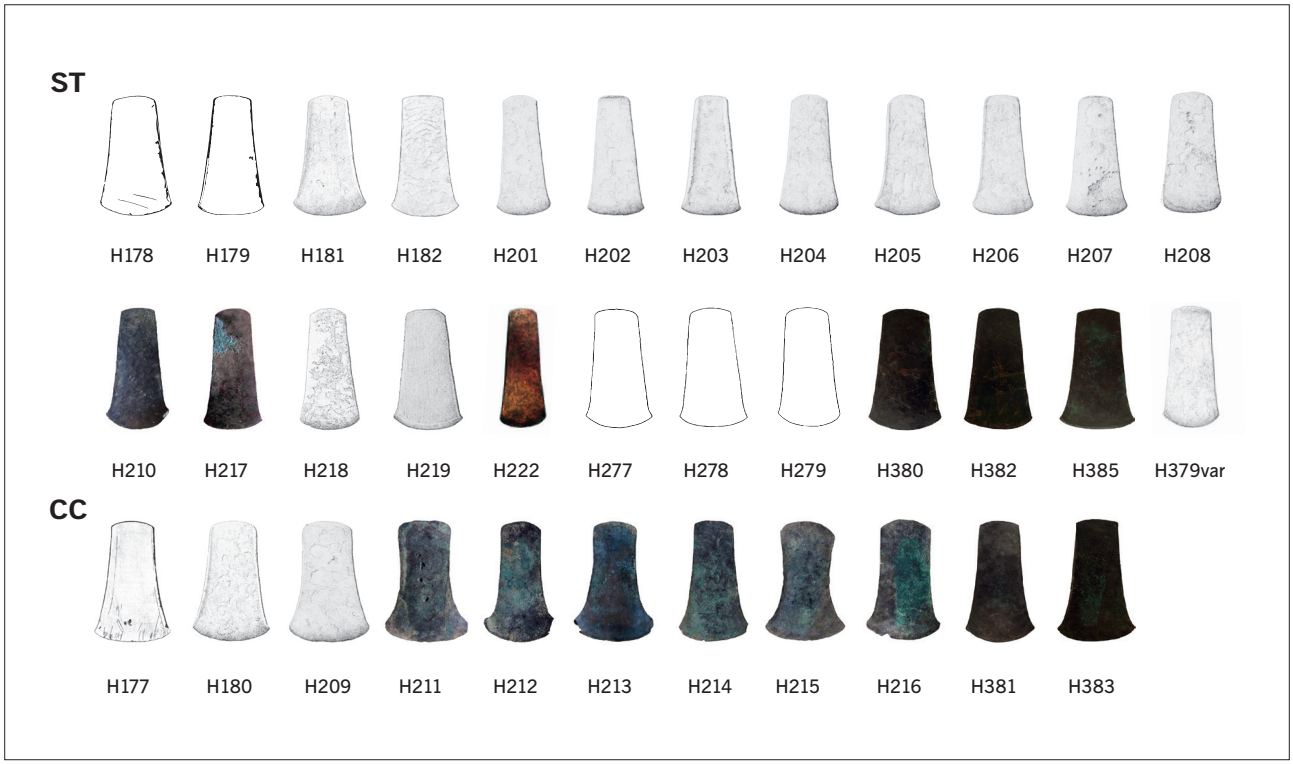


Fig. 8 Yunclillos axes (35). All shapes appear scaled to the same length in order to allow morphological comparability. ST straight profile; CC concave profile. For references, see Annex 1.

Abb. 8 *Yunclillos-Beile (35). Alle Exemplare wurden zwecks morphologischer Vergleichbarkeit auf dieselbe Länge skaliert. ST gerades Profil; CC konkaves Profil. Siehe Annex 1 für weitere Informationen.*

1. YUNCLILLOS															
SHAPE			**BUTT**			**SYMMETRY**		**SLENDERNESS**			**CUTTING EGE**			**FLANGE SHAPE**	
REC	TRA	TRI	THIN	MED	WIDE	HIGH	LOW	HIGH	MED	LOW	F0	F1	F2	ST	CC
18	15	0	0	0	33	0	33	0	22	11	1	27	5	22	11
55 %	45 %	0 %	0 %	0 %	100 %	0 %	100 %	0 %	67 %	33 %	3 %	82 %	15 %	67 %	33 %

	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Weight (g)
MEAN	255.9	124.1	73.7	78.5	110.6	27.0	1158.0
STDEV	24.5	23.2	14.6	13.3	18.7	9.5	181.0
MIN	221.0	90.0	50.0	57.0	78.8	13.6	941.0
MAX	311.0	175.0	111.0	108.0	158.0	60.0	1614.0

Tab. 9 Morphometric classification and metrical variability of Yunclillos axes without variants and cases with missing information (33). Characteristic traits are highlighted.

Tab. 9 *Morphometrische Klassifikation und metrische Variabilität der Yunclillos-Beile ohne Varianten sowie bei unvollständigen Datensätzen (33). Charakteristische Merkmale sind hervorgehoben.*

defined as the only taxa with a wide butt (TA) and low symmetry (SB). Their general shape can be either trapezoidal (TRA) or rectangular (REC) (Tab. 9). As already seen (Fig. 7), their metrical dimensions are also larger than all other axes. As predicted by the PCA, they are also the heaviest axes; where this dimension has been measured (n = 19), values vary between c. 940–1614 g. The Yunclillos taxon's distribution is focused on inner Iberia, far from the sea and coasts. More specifically, they appear in central Andalusia, Southern Meseta, Ebro Valley, and, exceptionally, in the north. Most seem to have been found in hoards, together with other axes but with no other metal objects. The chemical composition of more than three quarters of the axes (n = 27) indicates arsenical copper with a high arsenic content (c. 0.5–3.0 %).

LARGE ASIEGO: REC-TM-EA-F1

The Large Asiego taxon includes 29 axes, of which four are variants, and no moulds (Fig. 9). This taxon is composed, among others, of all the axes from the name-giving deposit and forms a very distinct metrical group (Fig. 7). Most specimens present straight (RT) flanges, medium-sized butts

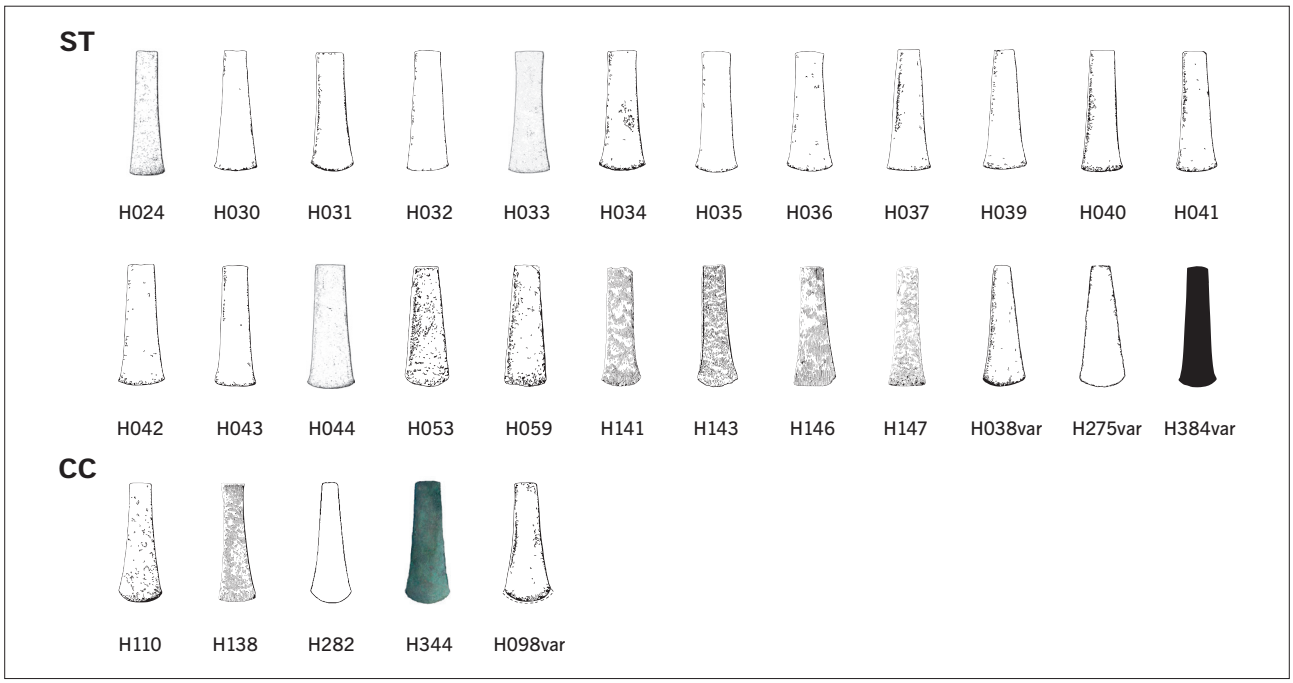


Fig. 9 Large Asiego axes (29). All shapes appear scaled to the same length in order to allow morphological comparability. ST straight profile; CC concave profile. For references, see Annex 1.

Abb. 9 *Große Asiego-Beile (29). Alle Exemplare wurden zwecks morphologischer Vergleichbarkeit auf dieselbe Länge skaliert. ST gerades Profil; CC konkaves Profil. Siehe Annex 1 für weitere Informationen.*

2. LARGE ASIEGO

SHAPE			BUTT			SYMMETRY		SLENDERNESS			CUTTING EGE			FLANGE SHAPE	
REC	TRA	TRI	THIN	MED	WIDE	HIGH	LOW	HIGH	MED	LOW	F0	F1	F2	ST	CC
20	5	0	5	20	0	17	8	22	3	0	1	24	0	21	4
80 %	20 %	0 %	20 %	80 %	0 %	68 %	32 %	88 %	12 %	0 %	4 %	96 %	0 %	84 %	16 %

	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Weight (g)
MEAN	185.0	64.8	36.4	39.9	56.0	10.0	833
STDEV	10.9	4.8	4.4	3.5	4.2	4.2	153
MIN	165.0	54.0	24.9	31.8	48.3	5.0	695
MAX	210.0	72.0	44.0	46.0	63.0	19.0	1095

Tab. 10 Morphometric classification and metrical variability of Large Asiego axes without variants (25). Characteristic traits are highlighted.

Tab. 10 *Morphometrische Klassifikation und metrische Variabilität der Großen Asiego-Beile ohne Varianten (25). Charakteristische Merkmale sind hervorgehoben.*

(TM), and a pronounced slenderness (descriptor R1 being always ≤ 0.62). We only have the weight of 6 axes, and they oscillate between 695–1095 g (Tab. 10) or even 1685 g if a variant from Estepa (H384) is included, resulting in big and massive axes. This taxon has a prevalent distribution in the central–western axis of Iberia, with a maximum concentration in the north and north-west, and a secondary one in the south-west. Moreover, abundant chemical data (n = 21) show that arsenic and tin bronzes follow different spatial patterns. Whereas the first concentration appears mostly in the north, in the deposit of Asiego itself, the second concentration is exclusive to Western Iberia.

SMALL ASIEGO: REC/TRA-TE-EA

The Small Asiego consists of 35 cases, including 32 flat axes, 1 flanged axe, and 2 moulds (Fig. 10). As in the case of Large Asiego axes, the principal distinction of this taxon is a pro-

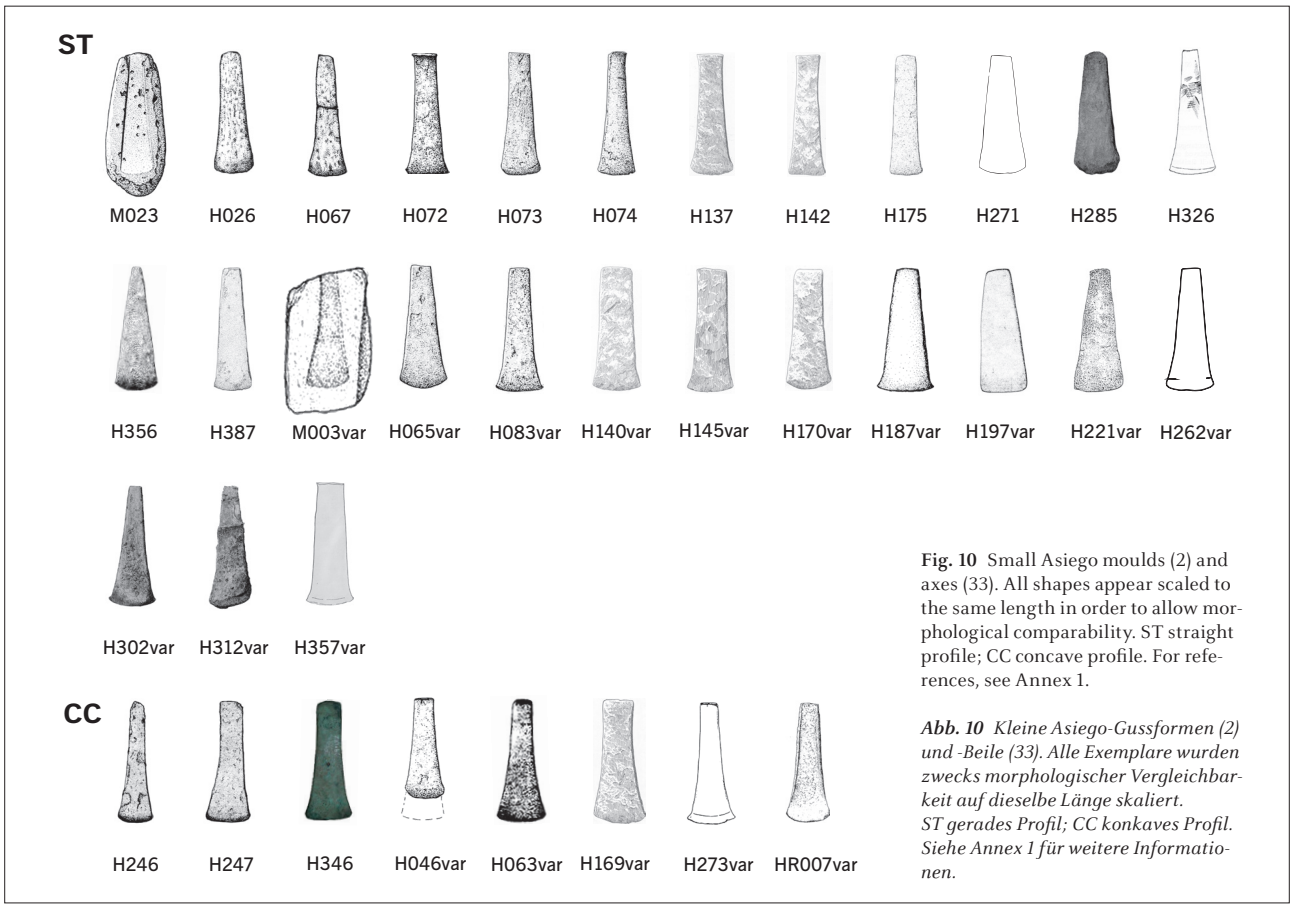


Fig. 10 Small Asiego moulds (2) and axes (33). All shapes appear scaled to the same length in order to allow morphological comparability. ST straight profile; CC concave profile. For references, see Annex 1.

Abb. 10 *Kleine Asiego-Gussformen (2) und -Beile (33). Alle Exemplare wurden zwecks morphologischer Vergleichbarkeit auf dieselbe Länge skaliert. ST gerades Profil; CC konkaves Profil. Siehe Annex 1 für weitere Informationen.*

3. SMALL ASIEGO															
SHAPE			BUTT			SYMMETRY		SLENDERNESS			CUTTING EGE			FLANGE SHAPE	
REC	TRA	TRI	THIN	MED	WIDE	HIGH	LOW	HIGH	MED	LOW	F0	F1	F2	ST	CC
10	7	0	17	0	0	17	1	17	0	0	4	13	0	14	3
59 %	41 %	0 %	100 %	0 %	0 %	94 %	6 %	100 %	0 %	0 %	24 %	76 %	0 %	82 %	18 %

	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Weight (g)
MEAN	127.2	41.1	19.7	24.6	33.6	6.5	189
STDEV	16.6	6.5	6.0	4.5	6.0	2.2	100
MIN	106.0	32.0	12.0	17.2	26.6	2.0	78
MAX	159.0	57.0	31.0	36.0	51.0	10.8	407

Tab. 11 Morphometric classification and metrical variability of Small Asiego axes and casting matrices without variants (17). Characteristic traits are highlighted.

Tab. 11 *Morphometrische Klassifikation und metrische Variabilität der Kleinen Asiego-Beile und -Gussmatrizen ohne Varianten (17). Charakteristische Merkmale sind hervorgehoben.*

nounced slenderness (descriptor R1 being < 0.6). It always presents a narrow butt. The shape of the body can be rectangular or trapezoidal with straight flanges (Tab. 11). However, more than half of the axes (18) are variants that do not fulfil one or more of the classificatory criteria, suggesting that these very simply shaped forms could be produced in a non-standardised casting and forging procedure. This is also confirmed by the available weight measurements (14), which vary between 78–407 g. This taxon has a very extensive distribution throughout Iberia, excluding only central and north Portugal, the Northern Meseta, and the Balearic Islands. Well defined pieces and variants do not show different dis-

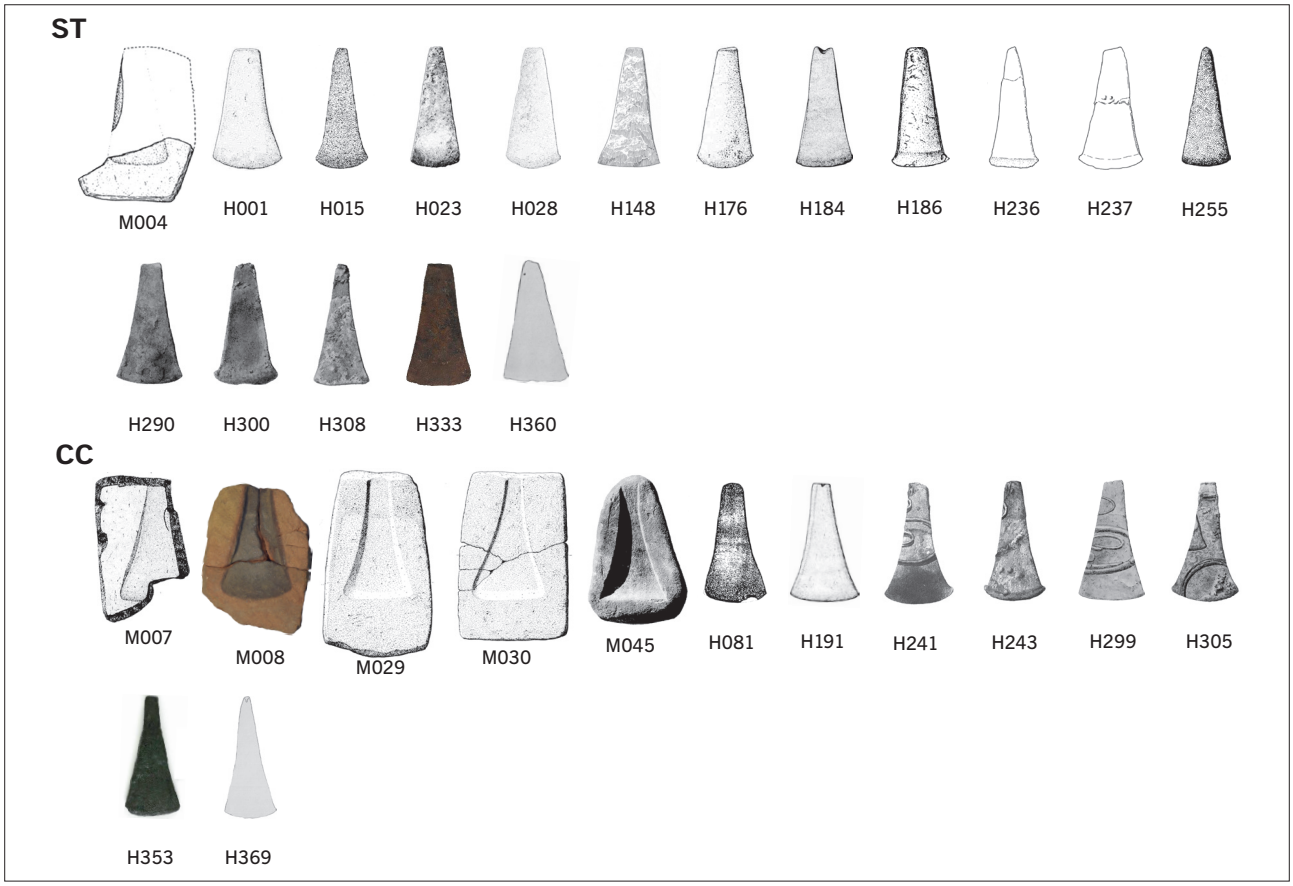


Fig. 11 TRI-TE-SA moulds (6) and axes (24). All shapes appear scaled to the same length in order to allow morphological comparability. ST straight profile; CC concave profile. For references, see Annex 1.

Abb. 11 *Gussformen (6) und Beile (24) vom Taxon TRI-TE-SA. Alle Exemplare wurden zwecks morphologischer Vergleichbarkeit auf dieselbe Länge skaliert. ST gerades Profil; CC konkaves Profil. Siehe Annex 1 für weitere Informationen.*

4. TRI–TE–SA

SHAPE			BUTT			SYMMETRY		SLENDERNESS			CUTTING EGE			FLANGE SHAPE	
REC	TRA	TRI	THIN	MED	WIDE	HIGH	LOW	HIGH	MED	LOW	F0	F1	F2	ST	CC
0	0	30	30	0	0	30	0	10	20	0	7	23	0	17	13
0 %	0 %	100 %	100 %	0 %	0 %	100 %	0 %	33 %	67 %	0 %	23 %	77 %	0 %	57 %	43 %

	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Weight (g)	Weight, incl. PC1 (g)
MEAN	117.7	59.0	16.2	30.5	46.6	8.0	264	262
STDEV	30.1	16.2	5.4	5.6	14.5	3.8	195	164
MIN	77.0	35.0	5.5	21.0	26.0	0.0	77	77
MAX	195.0	90.0	28.0	44.0	77.0	21.0	711	711

Tab. 12 Morphometric classification and metrical variability of TRI-TE-SA axes and casting matrices (30). Characteristic traits are highlighted.

Tab. 12 *Morphometrische Klassifikation und metrische Variabilität der Beile und Gussmatrizen vom Taxon TRI-TE-SA (30). Charakteristische Merkmale sind hervorgehoben.*

tribution patterns, contrary to the chemical compositions, which are available for more than one half of the axes (25), including variants. While copper axes with c. 0.5–2.0 % of arsenic appear in the south and south-east of the peninsula, tin bronzes with heterogeneous amounts of Sn and other elements appear either in South-Western Iberia or south of the Pyrenees Mountain range. So far, nothing suggests that these regions were supplied from a common productive centre.

Taxon TRI-TE-SA

The TRI-TE-SA taxon includes 30 cases, including 24 flat axes and 6 moulds (Fig. 11). They are strictly and exclusively formed by triangular shapes with strongly diverging flanges, a thin butt, a high symmetry, and a high- to mid-range slenderness (Tab. 12). Weight is available for around one third of the axes (11) but can be estimated based on the regression coefficient with PC1 for another 15 cases (Fig. 4). Values oscillate between 77–711 g (small and medium-sized axes). Contextually, this production is clearly related with the El Argar group of South-Eastern Iberia, where over half of the axes were found. Several axes and moulds also appear in the Levante. Their presence further north, up to the Atlantic coast, as well as in the south-west is sporadic. About one third of the axes have been analysed so far (10), and most of them contain relatively low contents of arsenic, which is characteristic of metal for El Argar axeheads in general.

Taxon TRI-TE-EB

So far, the TRI-TE-EB taxon only consists of 14 cases, including 6 flat axes, 3 flanged axes, and 5 casting matrices (Fig. 12).

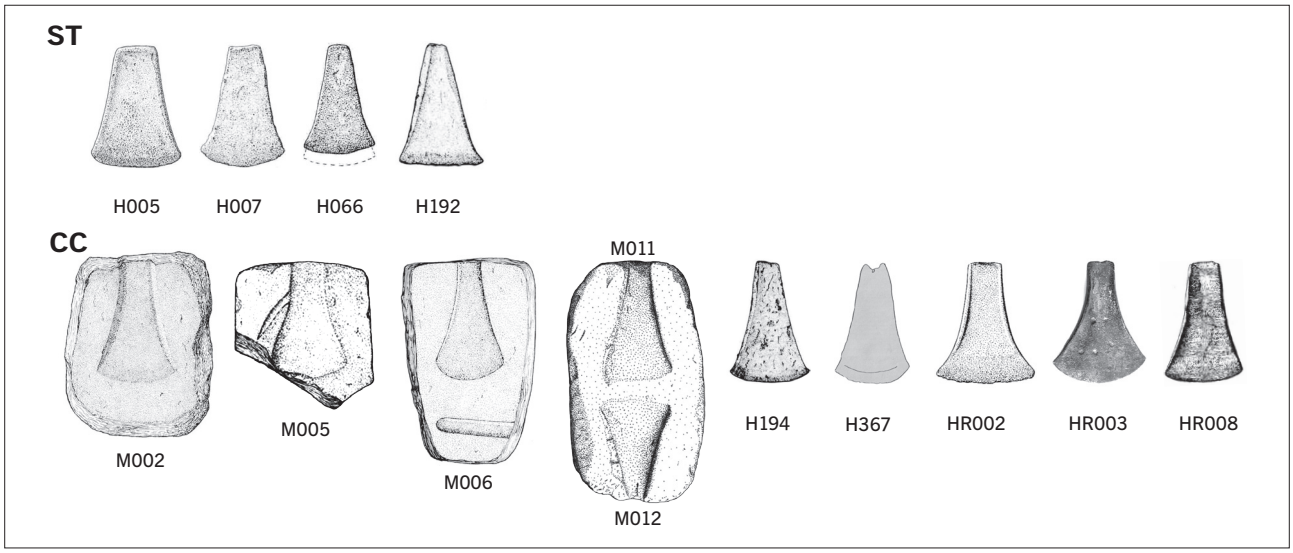


Fig. 12 TRI-TE-EB casting matrices (5) and axes (9). All shapes appear scaled to the same length in order to allow morphological comparability. ST straight profile; CC concave profile. For references, see Annex 1.

Abb. 12 *Gussmatrizen (5) und Beile (9) vom Taxon TRI-TE-EB. Alle Exemplare wurden zwecks morphologischer Vergleichbarkeit auf dieselbe Länge skaliert. ST gerades Profil; CC konkaves Profil. Siehe Annex 1 für weitere Informationen.*

5. TRI–TE–EB

SHAPE			BUTT			SYMMETRY		SLENDERNESS			CUTTING EGE			FLANGE SHAPE	
REC	TRA	TRI	THIN	MED	WIDE	HIGH	LOW	HIGH	MED	LOW	F0	F1	F2	ST	CC
0	0	14	14	0	0	4	10	0	0	14	0	11	2	4	10
0 %	0 %	100 %	100 %	0 %	0 %	29 %	71 %	0 %	0 %	100 %	0 %	85 %	15 %	29 %	71 %

	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Weight (g)	Weight, incl. PC1 (g)
MEAN	98.9	67.5	22.4	39.5	49.9	10.5	154	275
STDEV	24.2	15.5	5.4	5.0	16.3	4.0	76	168
MIN	63.0	45.0	10.5	33.7	30.0	2.9	63	63
MAX	150.0	98.0	30.0	50.0	85.0	18.0	282	635

Tab. 13 Morphometric classification and metrical variability of TRI-TE-EB axes and casting matrices (14). Characteristic traits are highlighted.

Tab. 13 *Morphometrische Klassifikation und metrische Variabilität der Beile und Gussmatrizen vom Taxon TRI-TE-EB (14). Charakteristische Merkmale sind hervorgehoben.*

Apart from their triangular shape and thin butt, the axes of this taxon are defined by a low slenderness, giving their bodies a squashed or compressed aspect (Tab. 13). Compared to most other taxa, in this case a relatively high number of wide cutting edges (F2) appear. According to six measured and five estimated weight measurements, the axes are small and, occasionally, medium-sized (63–635 g). Their distribution is concentrated in Eastern Iberia with some cases in the north. The notable number of moulds confirms their production at least in the Levante and the Northern Meseta. Only four axes have been analysed so far, and all are made exclusively of bronze with a notable amount of tin (c. 6–13 %).

Taxon TRA-TE-SA

The TRA-TE-SA taxon includes by far the largest number of cases (112), which can be divided into 90 flat axes, 3 flanged axes, and 19 casting matrices (Fig. 13). Probably, the still

Fig. 13a–b TRA-TE-SA casting matrices (20) and axes (93). All shapes appear scaled to the same length in order to allow morphological comparability. ST straight profile; CC concave profile. For references, see Annex 1.

Abb. 13a–b *Gussmatrizen (20) und Beile (93) vom Taxon TRA-TE-SA. Alle Exemplare wurden zwecks morphologischer Vergleichbarkeit auf dieselbe Länge skaliert. ST gerades Profil; CC konkaves Profil. Siehe Annex 1 für weitere Informationen.*

unpublished mould M085 (Fig. 2 and 13) also served to cast this taxon, if the damaged part of the axe butt is taken into account. These cases have in common a trapezoidal shape, thin butt, and high symmetry. Only two moulds and two matrices need to be classified as variants. The weight of 30 flat axes is known and can be estimated for another 68 by

6. TRA–TE–SA

SHAPE			BUTT			SYMMETRY		SLENDERNESS			CUTTING EGE			FLANGE SHAPE	
REC	TRA	TRI	THIN	MED	WIDE	HIGH	LOW	HIGH	MED	LOW	F0	F1	F2	ST	CC
0	105	0	105	0	0	105	0	41	63	1	11	93	1	38	67
0 %	100 %	0 %	100 %	0 %	0 %	100 %	0 %	39 %	60 %	1 %	10 %	89 %	1 %	36 %	64 %

	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Weight (g)	Weight, incl. PC1 (g)
MEAN	118.8	56.5	18.3	27.3	41.6	8.6	228	262
STDEV	23.4	13.0	4.9	4.9	11.8	3.2	137	145
MIN	72.0	32.0	10.0	15.0	21.2	0	45	38
MAX	180.0	87.0	33.0	40.0	74.0	17.5	552	683

Tab. 14 Morphometric classification and metrical variability of TRA-TE-SA axes and casting matrices without variants (105). Characteristic traits are highlighted.

Tab. 14 *Morphometrische Klassifikation und metrische Variabilität der Beile und Gussmatrizen vom Taxon TRA-TE-SA ohne Varianten (105). Charakteristische Merkmale sind hervorgehoben.*

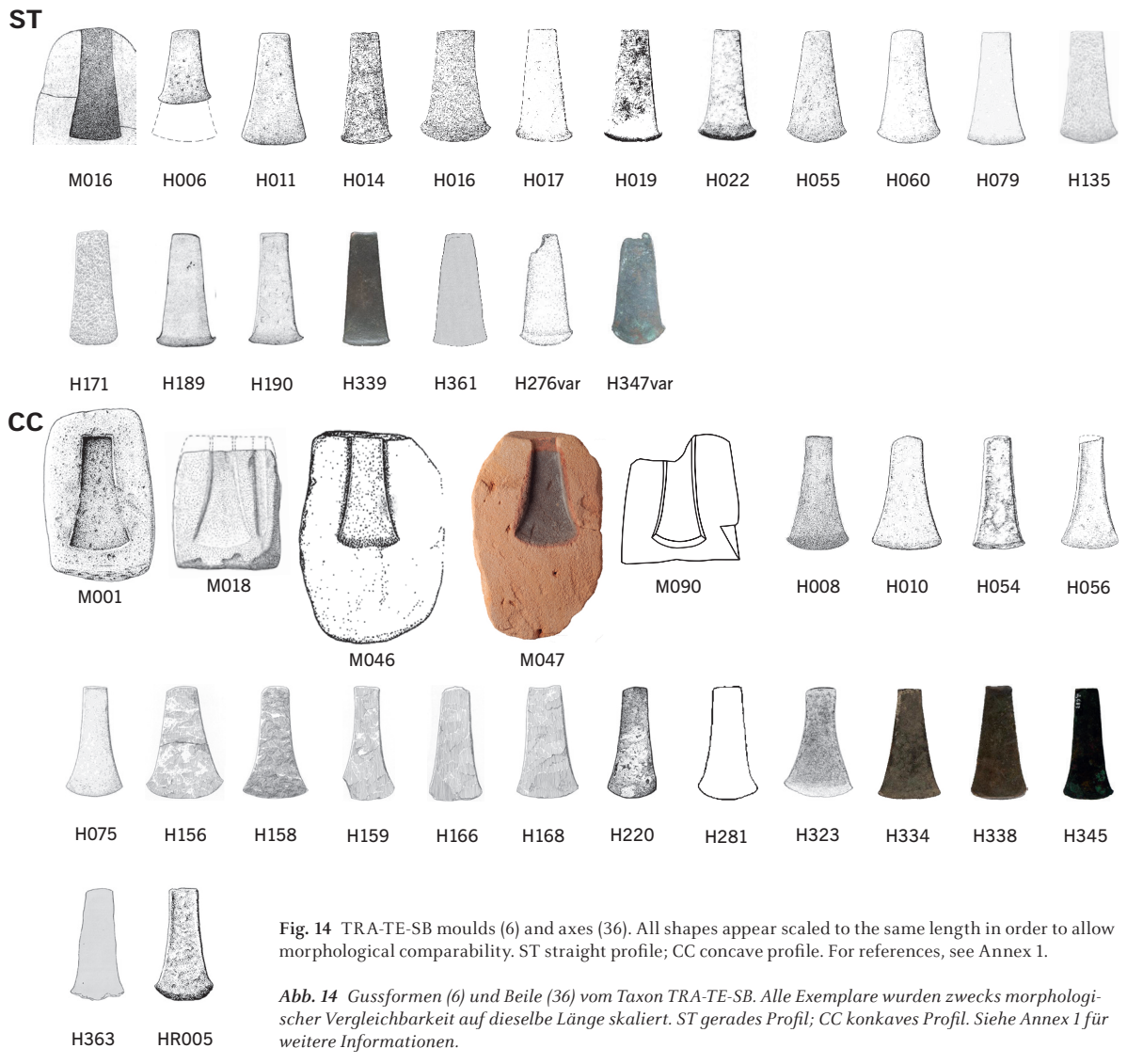


Fig. 14 TRA-TE-SB moulds (6) and axes (36). All shapes appear scaled to the same length in order to allow morphological comparability. ST straight profile; CC concave profile. For references, see Annex 1.

Abb. 14 *Gussformen (6) und Beile (36) vom Taxon TRA-TE-SB. Alle Exemplare wurden zwecks morphologischer Vergleichbarkeit auf dieselbe Länge skaliert. ST gerades Profil; CC konkaves Profil. Siehe Annex 1 für weitere Informationen.*

7. TRA–TE–SB

SHAPE			BUTT			SYMMETRY		SLENDERNESS			CUTTING EGE			FLANGE SHAPE	
REC	TRA	TRI	THIN	MED	WIDE	HIGH	LOW	HIGH	MED	LOW	F0	F1	F2	ST	CC
0	40	0	40	0	0	0	40	0	31	9	4	37	0	17	23
0 %	100 %	0 %	100 %	0 %	0 %	0 %	100 %	0 %	78 %	22 %	10 %	90 %	0 %	42 %	58 %

	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Weight (g)	Weight, incl. PC1 (g)
MEAN	110.2	56.9	27.0	35.3	44.2	9.2	338.0	323.0
STDEV	22.0	11.7	4.0	4.4	10.1	2.9	209.0	148.0
MIN	63.0	34.0	15.0	24.0	20.0	4.0	64.0	64.0
MAX	152.0	86.0	33.0	44.0	68.0	15.0	751.0	751.0

Tab. 15 Morphometric classification and metrical variability of TRA-TE-SB axes and casting matrices without variants (40). Characteristic traits are highlighted.

Tab. 15 *Morphometrische Klassifikation und metrische Variabilität der Beile und Gussmatrizen vom Taxon TRA-TE-SB ohne Varianten (40). Charakteristische Merkmale sind hervorgehoben.*

applying the regression factor established with PC1 (Fig. 4). A wide range of small and medium-sized axes was produced in this shape, ranging from estimated 38–683 g (Tab. 14).

TRA-TE-SA artefacts are clearly related to the El Argar group but also appear on the rest of the Mediterranean Iberia. Most were found in the south-east (c. 65 %) and, more specifically, in the burials of the eponymous site of El Argar itself. Moulds are particularly frequent in the Levante and the north-east. Few finds are present in regions adjacent to El Argar (Southern Meseta and the south-west), while they are rare in more remote areas. Little more than one quarter of the axes and one mould (M039) have been analysed chemically (n = 26). Most of them were made of copper with relatively low arsenic (c. 0.6–2.0 %). Few artefacts were tin bronzes or show traces of tin (M039), with or without significant amounts of arsenic (> 0.5 %).

Taxon TRA-TE-SB

The TRA-TE-SB consists of 42 cases, including 35 flat axes, 1 flanged axe, and 6 moulds (Fig. 14). Two of the axes represent variants of this taxon, strictly defined by a trapezoidal body, a narrow butt, and a low symmetry. They also tend to present a medium slenderness and a slightly cutting edge (F1). Their weight is known for 16 artefacts but can be inferred for another 24. While the range of weights is similar to other taxa (64–751 g), the main group is formed by medium-sized axes (Tab. 15). Although the moulds mostly appear towards the north-east, axes are distributed over most of the peninsula except for the central and north-western regions. Most of the chemical composition is known, including variants (n = 25). The main trace elements (As, Sn, Pb) are notably variable, with tin varying between > 1–18 %. Arsenic copper and tin bronze are equally represented.

Taxa TRA-TM-SB-ST

The TRA-TM-SB shaped axes and casting matrices are the only case where the chemical composition is correlated to profile of the flanges. While straight flanges (ST) regularly correlate with arsenical copper, concave shapes (CC) are exclusive to tin bronze axes.

TRA-TM-SB-ST consists of 13 cases, including 12 flat axes, 1 flanged axe, and no mould (Fig. 15). Two artefacts can

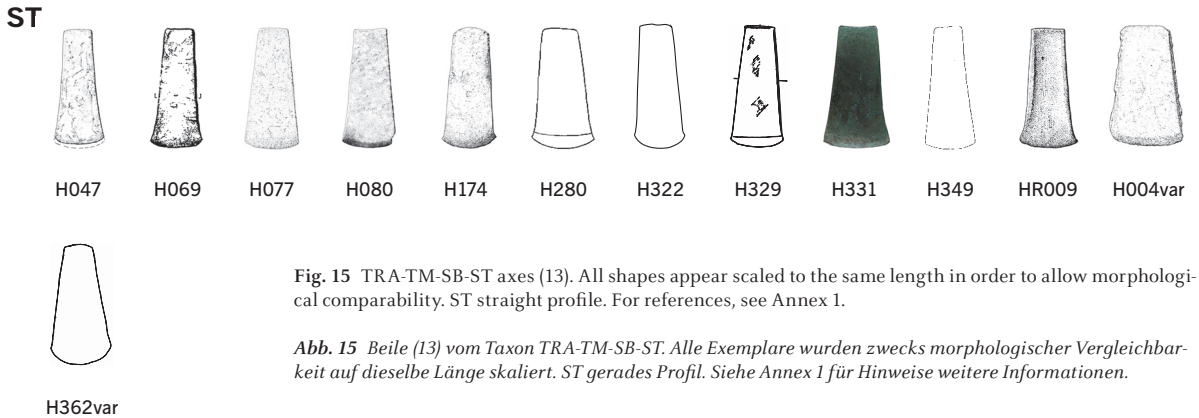


Fig. 15 TRA-TM-SB-ST axes (13). All shapes appear scaled to the same length in order to allow morphological comparability. ST straight profile. For references, see Annex 1.

Abb. 15 *Beile (13) vom Taxon TRA-TM-SB-ST. Alle Exemplare wurden zwecks morphologischer Vergleichbarkeit auf dieselbe Länge skaliert. ST gerades Profil. Siehe Annex 1 für Hinweise weitere Informationen.*

8. TRA–TM–SB–ST

SHAPE			BUTT			SYMMETRY		SLENDERNESS			CUTTING EGE			FLANGE SHAPE	
REC	TRA	TRI	THIN	MED	WIDE	HIGH	LOW	HIGH	MED	LOW	F0	F1	F2	ST	CC
0	11	0	0	11	0	0	11	0	9	2	4	7	0	11	0
0 %	100 %	0 %	0 %	100 %	0 %	0 %	100 %	0 %	82 %	18 %	36 %	64 %	0 %	100 %	0 %

	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Weight (g)	Weight, incl. PC1 (g)
MEAN	155.1	69.4	40.4	48.1	61.4	11.1	650	639
STDEV	23.9	7.6	5.5	6.2	7.6	3.8	232	201
MIN	113.0	58.0	34.0	40.0	46.0	6.0	416	416
MAX	196.0	83.0	49.0	58.0	72.4	20.0	1058	1058

Tab. 16 Morphometric classification and metrical variability of TRA-TM-SB-ST axes without variants (10). Characteristic traits are highlighted.

Tab. 16 *Morphometrische Klassifikation und metrische Variabilität der Beile und Gussmatrizen vom Taxon TRA-TM-SB-ST ohne Varianten (10). Charakteristische Merkmale sind hervorgehoben.*

be included as variants. The seven available weight measurements can be increased to a total of ten using the regression factor of PC1. The values correspond to middle and large size axes (Tab. 16). They show a very wide distribution over the Iberian Peninsula, excluding only the Levante, the southeast, and the Balearic Islands. Their highest concentration is observed in the northern half of Iberia. Almost 70 % of the axes (n = 9) have been analysed chemically, revealing that all were made of arsenical copper, except one piece which was cast from more or less pure copper.

Taxon TRA-TM-SB-CC

The TRA-TM-SB-CC consists of 25 cases, including 23 flat axes, and 2 moulds (Fig. 16). Four axes are included as variants. As already stated, this taxon and TRA-TM-SB-ST only differ in terms of the shape of their flanges and metal composition (Tab. 17). Applying the established regression factor (Fig. 4), weight data can be extended from nine to 23 axes, which classify as medium to heavy pieces. Spatially, they clearly concentrate in the western half of the Iberian Penin-

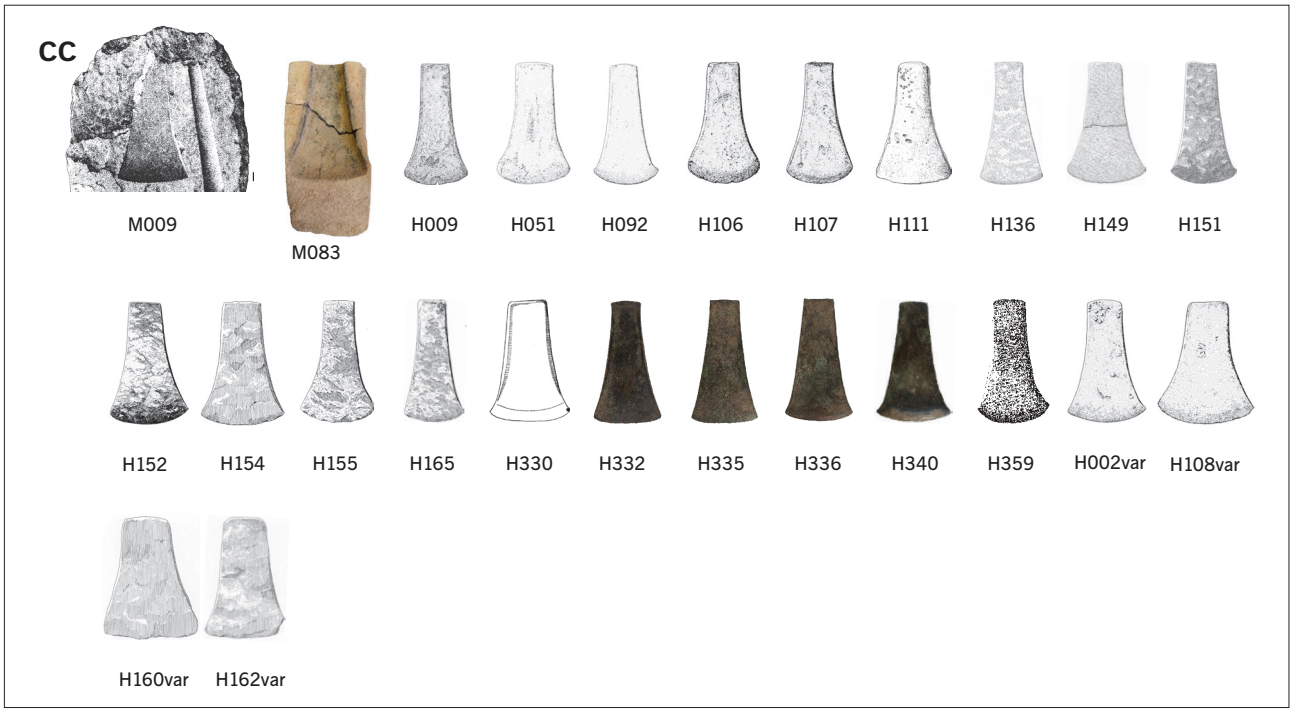


Fig. 16 TRA-TM-SB-CC moulds (2) and axes (23). All shapes appear scaled to the same length in order to allow morphological comparability. CC concave profile. For references, see Annex 1.

Abb. 16 *Gussformen (2) und Beile (23) vom Taxon TRA-TM-SB-CC. Alle Exemplare wurden zwecks morphologischer Vergleichbarkeit auf dieselbe Länge skaliert. CC konkaves Profil. Siehe Annex 1 für weitere Informationen.*

9. TRA–TM–SB–CC

SHAPE			BUTT			SYMMETRY		SLENDERNESS			CUTTING EGE			FLANGE SHAPE	
REC	TRA	TRI	THIN	MED	WIDE	HIGH	LOW	HIGH	MED	LOW	F0	F1	F2	ST	CC
0	21	0	0	21	0	0	21	0	9	12	1	17	3	0	21
0 %	100 %	0 %	0 %	100 %	0 %	0 %	100 %	0 %	43 %	57 %	5 %	81 %	14 %	0 %	100 %

	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Weight (g)	Weight, incl. PC1 (g)
MEAN	150.8	88.1	38.5	44.4	71.3	14.6	722	712
STDEV	14.7	10.2	3.6	4.5	9.9	4.9	125	113
MIN	121.0	72.0	33.0	36.1	51.6	5.0	536	489
MAX	182.0	112.0	45.0	53.0	90.0	24.0	991	991

Tab. 17 Morphometric classification and metrical variability of TRA-TM-SB-CC axes and casting matrices without variants (21). Characteristic traits are highlighted.

Tab. 17 *Morphometrische Klassifikation und metrische Variabilität der Beile und Gussmatrizen vom Taxon TRA-TM-SB-CC ohne Varianten (21). Charakteristische Merkmale sind hervorgehoben.*

sula, although the only two known moulds are from central Spain. Most of the axes and one mould have been chemically analysed. All cases are relatively rich tin bronzes (≥ 7.5 % of Sn). Tin was also identified on the mould of Cerro Lutero-A (M009), in Cuenca.

Taxon REC-TE-SB

The REC-TE-SB consists of 26 observations, including 20 flat axes, 2 flanged axes, and 4 moulds (Fig. 17). One mould and two axes are included as variants. They are defined by a rectangular shape, a thin butt, a low symmetry, and, usually, a medium slenderness. According to the available or inferred weight data (5 and 17 respectively), they were small-sized tools (Tab. 18), produced and circulating mostly in South-Eastern Iberia. Occasionally, axes can be found in the south-west, the north-east, and in the north, with no cases in between. More than half of the axes have been analysed chemically (14). They tend to be relatively rich tin bronzes (c. 6–12 % Sn). Only three axes are arsenical copper.

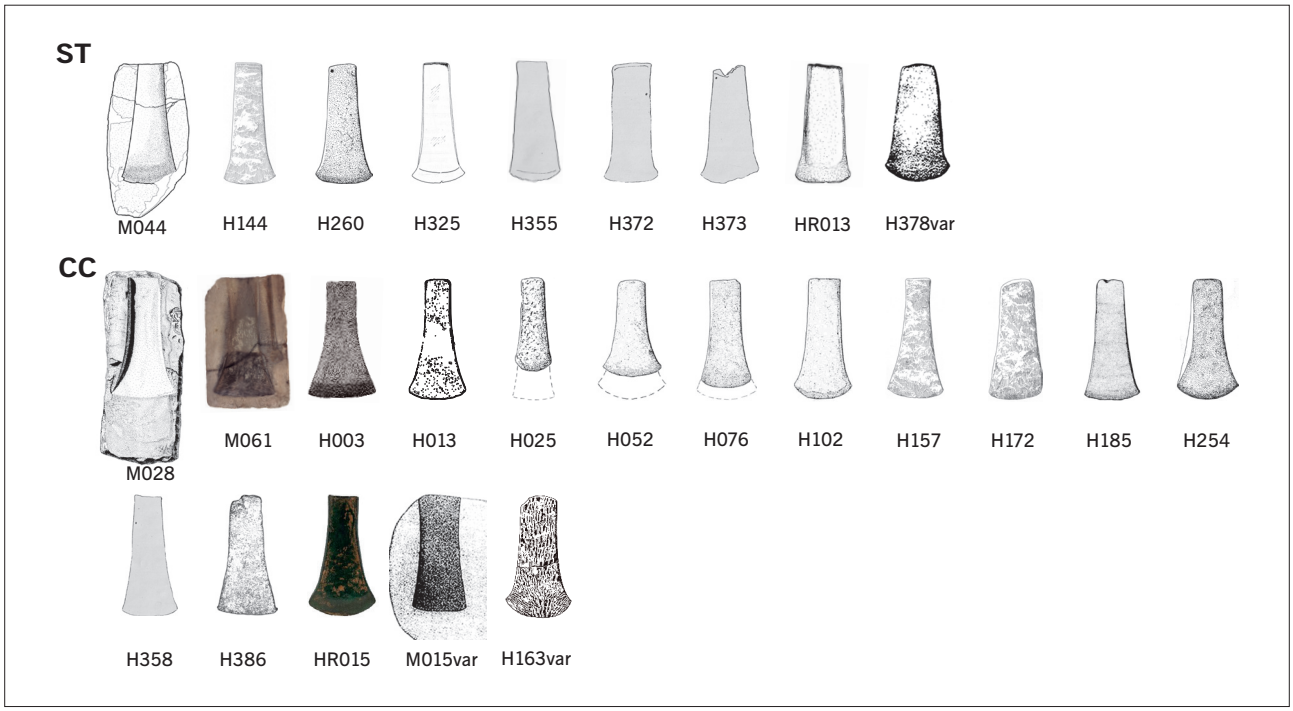


Fig. 17 REC-TE-SB moulds (4) axes (22). All shapes appear scaled to the same length in order to allow morphological comparability. ST straight profile; CC concave profile. For references, see Annex 1.

Abb. 17 *Gussformen (4) und Beile (22) vom Taxon REC-TE-SB. Alle Exemplare wurden zwecks morphologischer Vergleichbarkeit auf dieselbe Länge skaliert. ST gerades Profil; CC konkaves Profil. Siehe Annex 1 für weitere Informationen.*

10. REC–TE–SB

SHAPE			BUTT			SYMMETRY		SLENDERNESS			CUTTING EGE			FLANGE SHAPE	
REC	TRA	TRI	THIN	MED	WIDE	HIGH	LOW	HIGH	MED	LOW	F0	F1	F2	ST	CC
23	0	0	23	0	0	0	23	0	20	3	4	19	0	8	15
100 %	0 %	0 %	100 %	0 %	0 %	0 %	100 %	0 %	87 %	13 %	17 %	83 %	0 %	35 %	65 %

	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Weight (g)	Weight, incl. PC1 (g)
MEAN	113,9	55.0	28.2	31.9	42.0	8.7	171.6	315
STDEV	16.4	10.8	3.2	2.8	7.5	3.3	33.9	123
MIN	92.0	38.0	22.0	25.8	30.3	3.0	120.0	120
MAX	153.0	74.0	33.0	36.0	55.0	15.0	204.0	581

Tab. 18 Morphometric classification and metrical variability of REC-TE-SB axes and casting matrices without variants (23). Characteristic traits are highlighted.

Tab. 18 *Morphometrische Klassifikation und metrische Variabilität der Beile und Gussmatrizen vom Taxon REC-TE-SB ohne Varianten (23). Charakteristische Merkmale sind hervorgehoben.*

Taxon REC-TM-SB

Nineteen objects can be classified as REC-TM-SB based on their rectangular shapes, medium-sized butts, and low symmetry (Tab. 19). So far, 14 flat axes, three flanged axes, two complete moulds, and one incomplete mould are included (Fig. 18). Three of the axes represent variants. According to three direct weight measurements and the additional 10 values derived from the regression with PC1 (Fig. 4), this taxon represented middle-sized artefacts. They were widely distributed in Iberia, except in most of the Mediterranean regions and the Balearic Islands. The metal composition is known for most axes (n = 13) and even for residues identified on one mould (M010). While nearly half of the cases are of arsenical copper, the tin rich bronzes (c. 10 % Sn) concentrate in South-Western Iberia.

BUJÕES/BARCELOS: REC/TRA–TM/TE–EM–F2

Bujões/Barcelos is a well-known axe type of North-Western Iberia (Monteagudo 1977, 115–119; Senna-Martinez et al. 2013, 592), but it cannot be defined strictly in terms of body shape and symmetry (Tab. 20). Most of the axes show a rectangular and concave outline, and a medium slenderness. Its most distinctive traits are a high blade angle (dimension An3 ≥ 20°) combined with a large cutting-edge convexity (dimension F ≥ 13 mm). In our sample, 37 pieces fulfil these criteria, including 31 flat axes, 1 flanged axe, and 5 moulds, four of which are only partially preserved (Fig. 19). One of the axes is a variant. As the characteristic part of this axe type is the shape of the edge and not the body, forging and use wear can limit the possibilities to correctly identify these axes and their corresponding moulds. The seven

11. REC–TM–SB

SHAPE			BUTT			SYMMETRY		SLENDERNESS			CUTTING EGE			FLANGE SHAPE	
REC	TRA	TRI	THIN	MED	WIDE	HIGH	LOW	HIGH	MED	LOW	F0	F1	F2	ST	CC
16	0	0	0	16	0	0	16	0	11	5	0	15	1	6	10
100 %	0 %	0 %	0 %	100 %	0 %	0 %	100 %	0 %	69 %	31 %	0 %	94 %	6 %	37 %	63 %

	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Weight (g)	Weight, incl. PC1 (g)
MEAN	145.3	71.8	41.7	43.9	59.5	10.8	471	623
STDEV	12.4	8.6	4.3	3.7	6.3	2.5	62	113
MIN	124.5	59.0	35.0	36.0	49.0	4.0	421	421
MAX	172.0	95.0	50.0	50.0	71.7	14.0	558	816

Tab. 19 Morphometric classification and metrical variability of REC-TM-SB axes and casting matrices without variants (16). Characteristic traits are highlighted.

Tab. 19 *Morphometrische Klassifikation und metrische Variabilität der Beile und Gussmatrizen vom Taxon REC-TM-SB ohne Varianten (16). Charakteristische Merkmale sind hervorgehoben.*

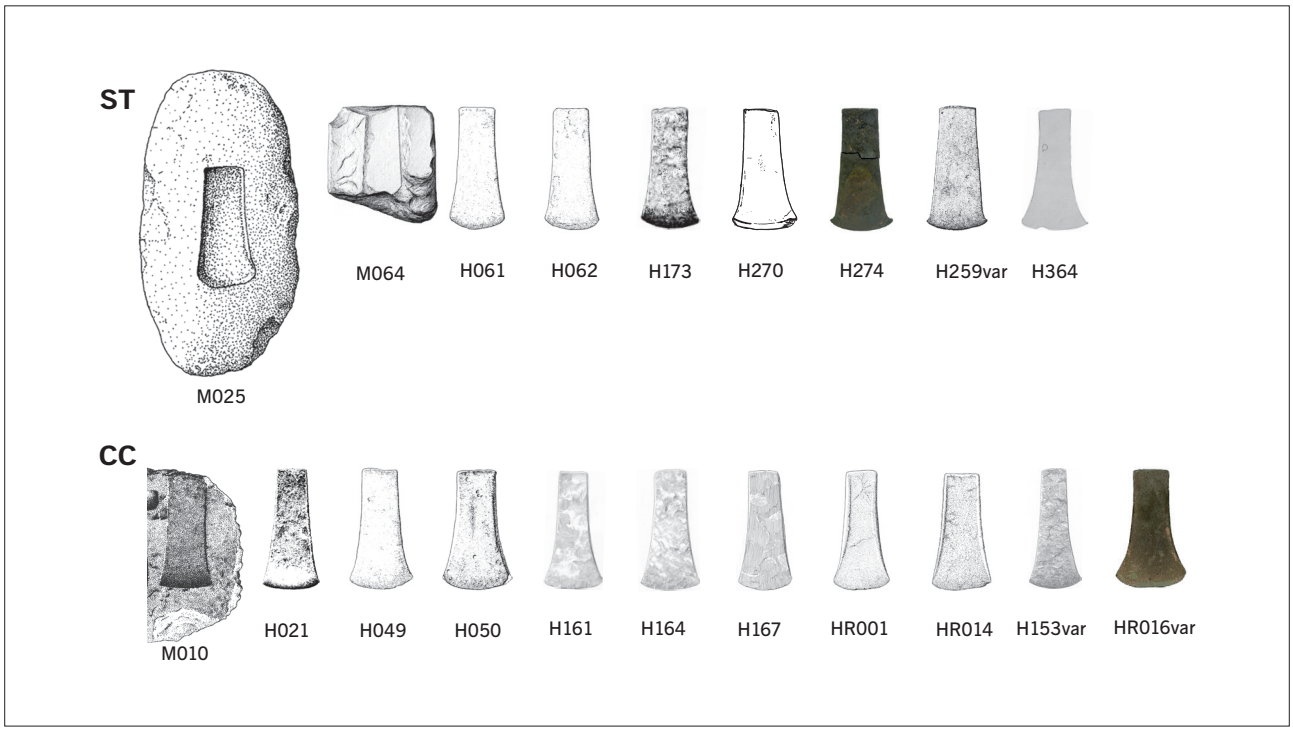


Fig. 18 REC-TM-SB moulds (3) and axes (17). All shapes appear scaled to the same length in order to allow morphological comparability. ST straight profile; CC concave profile. For references, see Annex 1.

Abb. 18 *Gussformen (3) und Beile (17) vom Taxon REC-TM-SB. Alle Exemplare wurden zwecks morphologischer Vergleichbarkeit auf dieselbe Länge skaliert. ST gerades Profil; CC konkaves Profil. Siehe Annex 1 für weitere Informationen.*

known weight measurements and the 21 inferred values mostly correspond to medium-sized axes, produced and circulating in the north-west. All contextualised axes (8) come from hoards of variable composition. All axes analysed so far (n = 16) are made of tin bronze (> 5 % Sn), as has already been indicated for a similar type of axes (Senna-Martinez et al. 2013). The presence of two Bujões/Barcelos type axes on the Balearic Islands requires a more detailed discussion (see below, Results 3).

In addition to the 9 taxa and 3 conventional types identified so far, one mould and one flanged axe belong to the taxa REC-TE-SA (Tab. 21). Given their apparent minor importance, they will not be analysed further in this study. Few other combinations in terms of body shape, butt width, and symmetry or slenderness have been observed so far. As the increase in the number of observations from 224, when the first PCA and morphometric analysis was carried out, to 364 has not lead to definitions of new taxa or to a modification of

12. BUJÕES/BARCELOS

SHAPE			BUTT			SYMMETRY		SLENDERNESS			CUTTING EGE			FLANGE SHAPE	
REC	TRA	TRI	THIN	MED	WIDE	HIGH	LOW	HIGH	MED	LOW	F0	F1	F2	ST	CC
23	9	0	13	19	0	12	20	3	24	5	0	0	32	2	30
72 %	28 %	0 %	41 %	59 %	0 %	37 %	63 %	9 %	75 %	16 %	0 %	0 %	100 %	6 %	94 %

	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Weight (g)	Weight, incl. PC1 (g)
MEAN	151.7	77.4	32.9	35.7	52.3	22.4	497	540
STDEV	19.7	10.8	4.7	4.2	9.0	5.6	200	140
MIN	95.0	42.0	18.0	22.0	26.0	13.0	125	125
MAX	181.0	95.0	43.0	45.0	67.0	39.0	740	740

Tab. 20 Morphometric classification and metrical variability of Bujões/Barcelos axes and casting matrices without variants (32). Characteristic traits are highlighted.

Tab. 20 *Morphometrische Klassifikation und metrische Variabilität der Bujões/Barcelos-Beile und -Gussmatrizen ohne Varianten (32). Charakteristische Merkmale sind hervorgehoben.*

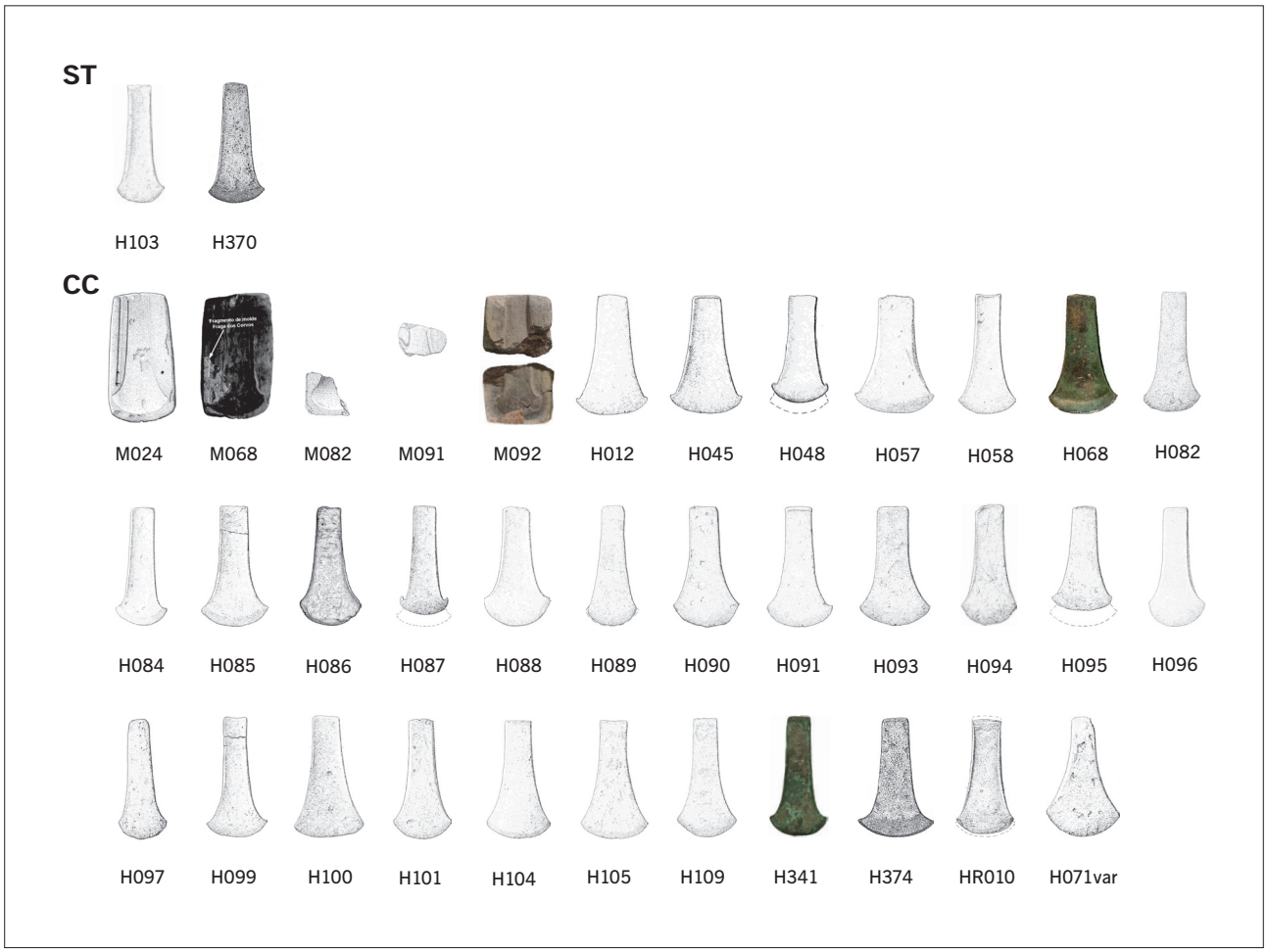


Fig. 19 Bujões/Barcelos moulds (5) and axes (32). All shapes appear scaled to the same length in order to allow morphological comparability. ST straight profile; CC concave profile. For references, see Annex 1.

Abb. 19 *Bujões/Barcelos-Gussformen (5) und -Beile (32). Alle Exemplare wurden zwecks morphologischer Vergleichbarkeit auf dieselbe Länge skaliert. ST gerades Profil; CC konkaves Profil. Siehe Annex 1 für weitere Informationen.*

the existing ones, it is not expected that the increase in the number of classified axes will lead to substantially different results in the Iberian Peninsula.

Results 3: Chronology

Despite of the apparent morphometrical simplicity of the flat axes, it is to be expected that not all taxa were produced and circulated throughout the entire Bronze Age. Unfortunately, the precise archaeological context of many axes remains unclear. Wherever possible, the following dating criteria have been used, in order of importance:

a) Absolute dates directly associated to axes.
b) Chronological range of the site where axes were found, according to ^{14}C dates.
c) Contextual coincidence in the same settlement, deposit, or mould of axes belonging to different taxa (Tab. 22).
d) Taxa with different chemical compositions have been used to propose internal chronological differences, given that arsenic coppers are usually older than tin bronzes.

The current periodisation of the Iberian Bronze Age (e.g., Lull et al. 2013) distinguishes between Early Bronze Age

	TRI		TRA				REC
TE	SA	EB	SA	SB	Asiego small		SB
TM	SA not observed	EB rare	SA rare	SB-ST	SB-CC	Asiego large	SB
TA	not observed		not observed		Yunclillos		not observed

Tab. 21 Overview of all axe taxa and types, except the Bujões/Barcelos, which cannot be defined only in terms of these criteria.

Tab. 21 *Überblick sämtlicher Beiltaxa und -typen (außer Bujões/Barcelos), die nicht allein aufgrund dieser Kriterien definiert werden können.*

	Yunclillos	TRI-TE-EAM	TRI-TE-EB	REC-TE-SA	TRA-TM-SB	TRA-TE-SB	REC-TE-SB	REC-TM-SB	Bujões/ Barcelos
Large Asiego	Estepa H380–H385								Codeseda H098, H099
TRI-TE-EB		Mola Alta Serelles M004–M007							
Small Asiego		Mola Alta Serelles M003, M004, M007	Mola Alta Serelles M003, M005, M006	Bardena Cáseda HR006, HR007	Fábrica Euskalduna H174, H175				
TRA-TM-SB							El Otero MN H003–H004	Fuente Frieras H049, H050, H051/Cerro Lutero M009, M010/ Majaladares	
TRA-TE-SA						El Acequión H019, H021 Forat Tuta M018	Cuesta Negro M027, M028	El Acequión H020, H021	
REC-TM-SB						El Acequión H019, H021/ El Otero MS M015, M016	Fuente Frieras H049, H050, H052		

Tab. 22 Contextual coincidence of axes from different taxa. Taxa not included do not have any coincidence.

Tab. 22 *Vergesellschaftung von Beilen unterschiedlicher Taxa. Nicht aufgeführte Taxa kommen nicht mit anderen zusammen vor.*

(henceforth EBA, c. 2200–1800 BC), Middle Bronze Age (henceforth MBA, c. 1800–1550 BC), and Late Bronze Age (henceforth LBA, c. 1550–1250 BC). The Final Bronze Age (henceforth FBA, c. 1250–900 BC) is not included in this study, although some taxa continued to be used at least until the beginning of the Iron Age. All axe taxa are tentatively dated according to the still limited contextual and chronological information (Fig. 20).

The *Yunclillos* axes have usually been found in hoards with no other artefacts or independent chronological references. Two recent studies (Valério et al. 2018; Ruiz-Taboada et al. 2019, 74), based on axe typology and metal composition (Cu-As), point to a Late Copper Age or EBA date, in coexistence with Bell Beaker elements in some regions. The appearance of one Large Asiego axe (H384) in the hoard of Estepa indicates the synchrony between these two taxa, both appearing in hoards composed exclusively of flat axes. Despite the absence of moulds, both the metallographic data of two axes (H212 and H213) and the homogeneity of the taxon in terms of size and weight indicate the use of moulds, probably of single use (clay or sand).

Large Asiego axes also lack reliable chronological information. We propose the existence of two different productions which were separated in time. Based on typology, some researchers date the Asiego hoard to the EBA (Blas Cortina 1999; Blas Cortina 2011). This agrees with the Cu-As composition of the axes and with the appearance of one specimen (H384) in the Estepa hoard, containing mostly Yunclillos axes. Large Asiego and Yunclillos axes seem to mark an early moment of metal hoards in Iberia, composed exclusively by flat axes.

At a later stage, Large Asiego axeheads were produced from tin bronze. The only contextual information comes from two hoards with a different artefact combination. The Codeseda hoard includes two riveted daggers and a Bujões/Barcelos axe (H099), a taxon which can be dated in the MBA-LBA (see below). In the Santa Cruz hoard, a variant of REC-TE-SB (H163) was found with a TRA-TE-SB specimen (H156) and a bronze sickle dated to the FBA. The high tin content detected in some Large Asiego axes, such as the ones from the Codesada and Santa Cruz hoards, further supports the existence of a Late to Final Bronze Age production, at least in South-Western Iberia. Although no metallographic data is available, the absence of moulds and the homogeneity of the taxon indicates the use of single use moulds, probably made in clay or sand.

The *Small Asiego* taxon has scarce and unprecise chronological references. Radiometric dates are available for H221 from Castillo de Frías (c. 1960–1900 BC), H187 from Lloma del Betxí (c. 2082–1784 BC), and for the mould M003 from Mola Alta de Serelles (c. 2000–1550 BC). The exceptional presence of taxonomic variants in El Argar burials, where TRA-TE-SA and TRI-TE-SA form a characteristic grave good after 1800 BC (cf. Bonora Soriano in this volume), also suggests this taxon went out of use during the MBA. Based on their geographic distribution, Small Asiego artefacts of arsenical copper can be considered the characteristic axe taxon of the Early and Middle Argar periods (c. 2100–1750 BC). In contrast, axe H387, made of a Cu-Sn-Pb alloy, was found in hoard 2 of Cova de Muricecs in the north-east together with diverse metal objects typologically dating to the LBA or early FBA. The Cu-Sn flanged axe HR007 from the Bardena de Cáseda hoard supports a MBA-LBA dating.

The association of Small Asiego axes and casting matrices to other taxa allows us to establish some synchronies. A mould from the Mola Alta de Serelles combines the matri-

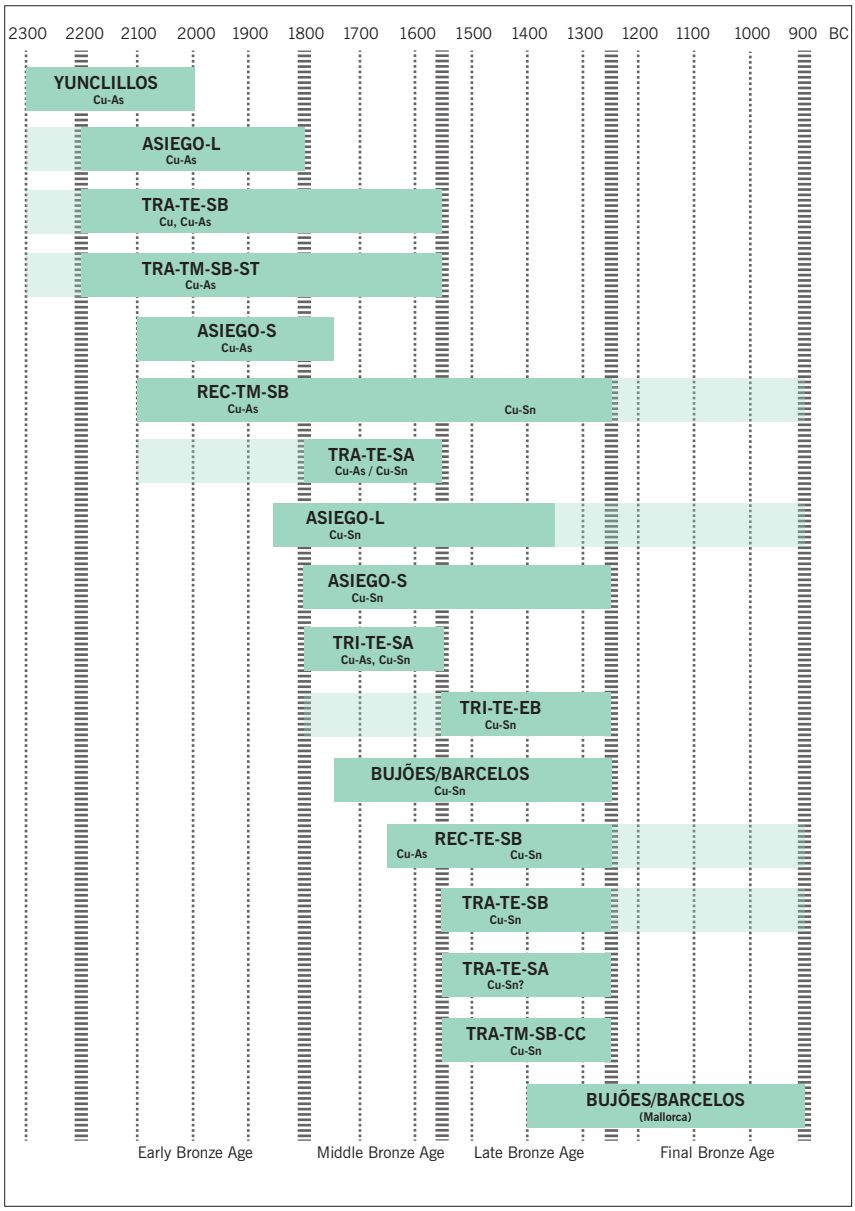


Fig. 20 Proposed time span of all axe taxa according to chronological, contextual, and chemical data.

Abb. 20 *Vorgeschlagene Zeitspannen aller Beiltaxa anhand von chronologischen, kontextuellen und chemischen Daten.*

ces of a Small Asiego variant (M003) with a TRI-TE-SA axe (M004). It was found in the same dwelling together with axe moulds belonging to TRI-TE-SA (M007) and TRI-TE-EB (M005 and M006). A Small Asiego axe (H175) appeared at Fábrica Euskalduna together with a TRA-TM-SB specimen (H174). Both are made of arsenical copper, the dominant metal before 1600 BC. A Small Asiego axe was also found in the hoard of Roufeiro, Ourense, together with a small variant of a Yunclillos axe (Monteagudo 1977, Taf. 143). The hoard is dated to the Early-Middle Bronze Age transition, c. 1900–1700 BC (Brandherm 2003, 134; 184). The already mentioned hoard from Bardena de Cáseda contained two bronze flanged axes: one Small Asiego (HR007) and the only specimen classifiable as an REC-TE-SA taxon (HR006). In sum, while the arsenical copper pieces seem to correspond to the EBA and early MBA (c. 2100–1750 BC) of the south-east, bronze equivalents probably started being used during the MBA in the south-west, the Ebro Valley, and the north-east. At least in this last region they seem to have continued in use until the LBA.

The *TRI-TE-SA* taxon includes ten axes from Argaric tombs (c. 1800/1750–1550 BC), mould M008 from Orpesa la Vella (c. 2009–1691 BC), H186 from Lloma del Betxí (c. 2117–1684 BC), M004 and M007 of Mola Alta de Serelles (c. 2000–1550 BC), and H184 from Cabezo Redondo (c. 1747–1333 BC). All these ranges point to an MBA date (c. 1800/1750–1550 BC). Even the specimen of Cabezo Redondo could be dated to the MBA based on its different morphometry in comparison to the other axes and moulds found in this settlement (e.g., H185, M060, M061). As already mentioned, the moulds of Mola Alta de Serelles provide some hints concerning the synchronicity with other taxa (Small Asiego and TRI-TE-EB). In sum, this taxon has a MBA date and was produced in El Argar and the Valencian Bronze Age.

Few chronological references are available for *TRI-TE-EB* axes. M005 and M006 of Mola Alta de Serelles (c. 2000–1550 BC) and H194 from La Horna (c. 1750–1300 BC) support a MBA to LBA date. The presence of three flanged axes (MBA–LBA) and the notable amount of tin (c. 6–13 %) con-

tent in many pieces also supports a production and circulation of this taxon between c. 1800–1250 BC.

The *TRA-TE-SA* axes represent the typical late El Argar axes. The abundant chronological data indicates two different phases of use. The first production phase (Cu-As and a few tin bronzes) started during the EBA but was dominant in the MBA. Chronological references are provided by H020 from El Acequión (c. 2100–2050 BC), M051 from Minferri (c. 1919–1746 BC), 43 axes from Argaric tombs (c. 1800/1750–1550 BC), the mould M027 from Cuesta del Negro (c. 1750–1550 BC), M013 from Loma del Lomo (c. 2189–1519 BC), H018 from Cerro de El Cuchillo (c. 1875–1548 BC), and M019 from Forat de la Tuta (c. 1670–1534 BC). The presence of three flanged axes does not contradict a MBA dating. Most of the specimens made of tin bronze can be dated to the LBA of the south-east and the Balearic Islands, as indicated by the moulds M081 from Cala Blanca (c. 1421–1300 BC), M041 from Murviedro (c. 1400–1200 BC), and M042 from Gatas (probably 1550–1300 BC). Synchrony with other taxa is attested by the M027–M028 double mould from Cuesta del Negro (with a REC-TE-SB matrix), three axes from El Acequión (TRA-TE-SB and REC-TM-SB), and two moulds from Forat de la Tuta (with a TRA-TE-SB matrix). In sum, most of TRA-TE-SA cases must be dated to the MBA (c. 1800/1750–1550 BC) although a slightly earlier date (EBA) cannot be excluded. They continued to be produced during the LBA, at least in the south-east and the Balearic Islands.

The spatial and chemical differences shown by the *TRA-TE-SB* taxon also point towards two different productions. An earlier one of EBA–MBA date includes arsenic and pure copper axes, most of which appear in the eastern half of Iberia. Chronological references are provided by H019 from El Acequión (c. 2100–2050 BC), H079 from Partida de las Naves, a hoard with an Atlantic type halberd that has recently been dated between the Late Copper Age (with Bell Beakers) and the EBA (without Beakers; Garrido-Pena et al. 2022), H220 from Gamonedo, a hoard that could be dated to the EBA according to their atypical (non-planoconvex) ingots and Cu-As composition (Blas Cortina 1999; Gómez Ramos 1993; Reguera-Galán et al. 2018), M090 from El Bordellet (c. 1850–1700 BC), M046 from Hoya Quemada (c. 1950–1655 BC), H017 from Cerro de El Cuchillo (c. 1950–1705 BC), and M018 from Forat de la Tuta (c. 1670–1534 BC).

Tin bronzes seem to represent a second phase, more characteristic of the western half of Iberia. H323 comes from Cueva del Moro de Alins del Monte (c. 1945–1470 BC), and H156 formed part of the hoard of Santa Cruz including a bronze sickle dated to the FBA, as well as a variant of an REC-TE-SB (H163) axe. A late dating is also suggested by the only flanged axe of this taxon (HR005 from Sierra de Carrodilla).

Synchrony with other taxa is attested by two axes from El Acequión, found in the same context as H019 (H020, TRA-TE-SA, and H021, REC-TM-SB), and by M018 from Forat de la Tuta, found together with a second mould (M019, TRA-TE-SA). These associations support the dating of axes made from arsenical copper to the MBA, while bronze specimens would mainly date to the LBA and even the FBA.

TRA-TM-SB axes show a long-lasting use throughout the Bronze Age. However, *TRA-TM-SB-ST* axes are distributed in most of Iberia and were made of arsenical copper. Their early date is supported by H080 from Majaladares (c. 1900–1700 BC) and by their synchrony with Small Asiego (H175 from Fábrica Euskalduna), another type with an early beginning. Additionally, a similar axe of Cu-As – not included in this study – has been found in the Bell Beaker burial 5 of Humanejos (Parla, Madrid) and dated c. 2400 BC (Garrido-Pena et al. 2019, 305).

Continuity is attested by one halberd type Cano, both roughly dated to the MBA–early LBA (see above; Schuhmacher 2002; Senna-Martinez et al. 2013, 592), and the context at Majaladares, including a REC-TM-SB axe (H274), a type known during the whole Bronze Age (see below). Surprisingly, HR009 from Arcos de Valdevez is made of Cu-As. It is the only (prototype?) flanged axe in our study with no tin bronze composition.

In contrast, *TRA-TM-SB-CC* axes are distributed in the south-east, south-west and north-west. A MBA to LBA date is suggested by the use of – relatively – rich tin bronze The sole chronological reference for *TRA-TM-SB-CC* axes is provided by M083 from La Serna (c. 1599–1460 BC). A certain synchrony existed with the REC-TM-SB[8] and REC-TE-SB taxa (H052, from the same hoard). The latter taxon supports a LBA end (see below).

Most *REC-TE-SB* axes are made from relatively rich tin bronze, although a few arsenical copper specimens have also been identified. Chronological data are limited to tin bronze axes or axes of unknown composition. They point to a date between the late MBA and LBA. The earliest date comes from M028 of Cuesta del Negro, recovered together with Argaric materials and with another die for a TRA-TE-SA axe (typical of El Argar group, see above). This may explain the few Cu-As axes documented, most from the south-east. The LBA date is attested by H386 from the Arbocer hoard (c. 1438–1306 BC) and H185 and M161 from Cabezo Redondo (c. 1747–1333 BC). We propose a LBA date for the latter as it also presents a die for casting pins with a spherical head, a type which is unknown in early periods. Additionally, this settlement experienced an intense occupation and metallurgy during the LBA (Hernández Pérez et al. 2016). Five more axe moulds come from this site. Although most of them are fragmented and difficult to classify, two possibly belong casted *REC-TE-SB* axes (M060 and M062). A variant of REC-TE-SB (H163) was found in the hoard of Santa Cruz together with a TRA-TE-SB specimen (H156), a bronze Large Asiego (H147), and a bronze sickle dated to the FBA. The axe H003 of the Valdevimbre hoard is also a REC-TE-SB and it provides further support to a LBA dating (Celis et al. 2007). The same hoard includes a Cano type halberd, currently dated by ^{14}C and contextual data to the MBA–LBA (Schuhmacher 2002; Senna-Martinez et al. 2013, 592).

Synchrony with other taxa is not particularly useful. The Fuente de Frieras hoard contained 2 REC-TM-SB axes (H049–H050) and one TRA-TM-SB (H051), but both types

8 M010, from Cerro Lutero, and H049–H050, from the Fuente de Frieras hoard.

have a long tradition throughout the Bronze Age. M015 from El Otero_MS has a die for casting a variant of REC-TE-SB axes and a second die (M016) for TRA-TE-SB axes, again a long-lasting taxon. In sum and according to geographical concentration of axes and moulds in the south-east and adjacent areas, this taxon probably started in late El Argar and became more frequent during the LBA with the development of new centres of power, such as Cabezo Redondo (Alicante).

Axes ascribed to the *REC-TM-SB* taxon were produced from arsenical copper as well as tin bronze. Chronological references are not abundant and point to a long-lasting taxon produced during the whole Bronze Age. The earliest dated axes are H021 from El Acequión (c. 2100–2050 BC) and H274 from Majaladares-exterior (c. 1900–1700 BC), both made of copper. We lack chronological information for bronze equivalents, but a MBA or later date can be expected for two flanged axes without chemical analyses. However, HR014 from Cova de Font Major probably dates de the FBA, according to the rest of metal types included in the hoard. Information on the synchrony with other taxa is more abundant. Matrices of REC-TM-SB appear combined with other taxa on the mould of Cerro Lutero (M009, TRA-TM-SB). Associations with other axes are known from El Acequión (H020, TRA-TE-SA and H019, TRA-TE-SB), Majaladares-exterior (H080, TRA-TM-SB), and the Fuente de Frieras hoard (H051, TRA-TM-SB, and H052, REC-TE-SB). This supports an EBA to MBA/LBA or even later chronology (e.g., Cova de Font Major).

Finally, the *Bujões/Barcelos* taxon represents a very well-defined production in compositional (tin bronze), spatial (mostly North-Western Iberia), and chronological terms. M068 from Fraga dos Corvos and M091 from A Sola were found in archaeological levels dated to c. 1700 and 1673–1527 BC, respectively. Both levels include evidence of tin bronze production. This coincides with the conventional dating of these axes (most of them found in hoards) between the MBA and the LBA, c. 1750–1250 BC (Senna-Martinez/Luís 2016a, 119). In fact, Bujões/Barcelos axes are often considered to be the first tin bronze objects produced in North-Western Iberia (Comendador Rey/Bettencourt 2011; Senna-Martinez/Luís 2016). From a contextual perspective, Bujões/Barcelos axes appear in combination with a variant of a Large Asiego axe (H098) made of bronze in the Codeseda hoard. In sum, Bujões/Barcelos axes can clearly be dated between the MBA–LBA (c. 1750–1250 BC).

A different group of Bujões/Barcelos axes in our data base is composed of the two axes from Cova de Sa Talaia, Mallorca (H370 and H374). Both come from a funerary cave dated to the Balearic Middle to Late Naviform period (c. 1400–1100 BC). However, other typologically similar axes (Es Mitjà Gran, Cas Corraler – not included in this study) continued in use during the FBA or Prototalaiotic Period (c. 1100–850 BC) and were associated with other metal objects in hoards (Delibes de Castro et al. 1988; Llull Estarellas et al. 2022; Salvà Simonet 2013; 2018). Considering the possible chronological gap, we cannot ensure the relationship of the Mallorcan axes with the Bujões/Barcelos taxon.

All in all, the still limited chronological anchorage points suggest that the rapid transition from the Copper to the Bronze Age, clearly visible in the settlement and funerary record, was not matched by the introduction of new axe types (Fig. 20). Yunclillos, Large Asiego, TRA-TE-SB, and TRA-TM-SB-ST probably appeared in the late Bell Beaker period, c. 2400 cal BC, and endured after 2200 BC. Such a diversity of axes might have been a further expression of the dynamic of metal production detected during the developed Bell Beaker period, for example, in the number and scale of copper mines (Blas Cortina 1999; Blas Cortina 2011; Escanilla 2016).

The EBA saw the introduction of Small Asiego and REC-TM-SB axes, both of which had a long duration in Iberia. A clear increase in the variability took place during the MBA, when axes with narrow butts (TE) became dominant. This change in the axe morphology allowed a reduction of the amount of copper required to produce each tool or weapon, indicating a further phase of metallurgical intensification. Other aspects of this development were the use of moulds with axe matrices and tin alloys.

Most of the taxa continued to be produced during the LBA. The only new axe type was the TRA-TM-SB-CC, a shape cast in bronze. At least the TRA-TE-SB, REC-TM-SB, REC-TE-SB (variant), and even Large Asiego axes, continued to be in use until the FBA, when new axe types, such as palstaves, were introduced.

Result 4: Production of metal axes in Bronze Age Iberia

The absence or low number of moulds with matrices matching several taxa and in certain regions, such as in South-Western Iberia (Fig. 3), implies that at least two different axe casting technologies existed, one working with and one without stone moulds. In chronological terms, the limited number of dated finds suggest that stone moulds with axe matrices were unknown before c. 1850 BC, the end of the EBA. No moulds can be related to Late Copper and Early Bronze Age taxa, such as Yunclillos, Large Asiego, or TRA-TM-SB-ST. Small Asiego and TRA-TM-SB-ST axes were likewise not (or only rarely) produced with moulds (Fig. 21).

In contrast to the EBA, the abundance of moulds during the MBA and LBA points towards an increase and larger standardisation of the production of axes after c. 1750 BC. The number of moulds can be seen as a proxy for the volume of production because their visibility in the archaeological record is not determined by the depositional practices of metals in tombs and hoards. This crucial technological change took place mostly in the Mediterranean part of Iberia and in the north-west, where the Bujões/Barcelos artefacts were produced with moulds. The above-mentioned increase in the axe taxa and the gradual introduction of tin bronze during the MBA can also be understood as part of this intensification process of metal and, specifically, axe production. Considering the number of matching casting matrices, the characteristic El Argar taxa TRA-TE-SA and TRI-TE-SA (Fig. 21) were the most intensely produced axeheads of the MBA. However, these moulds were also known in the other Mediterranean regions, including in the north-east. This unexpected finding provides further evidence of the wide-ranging contacts of El Argar with its periphery

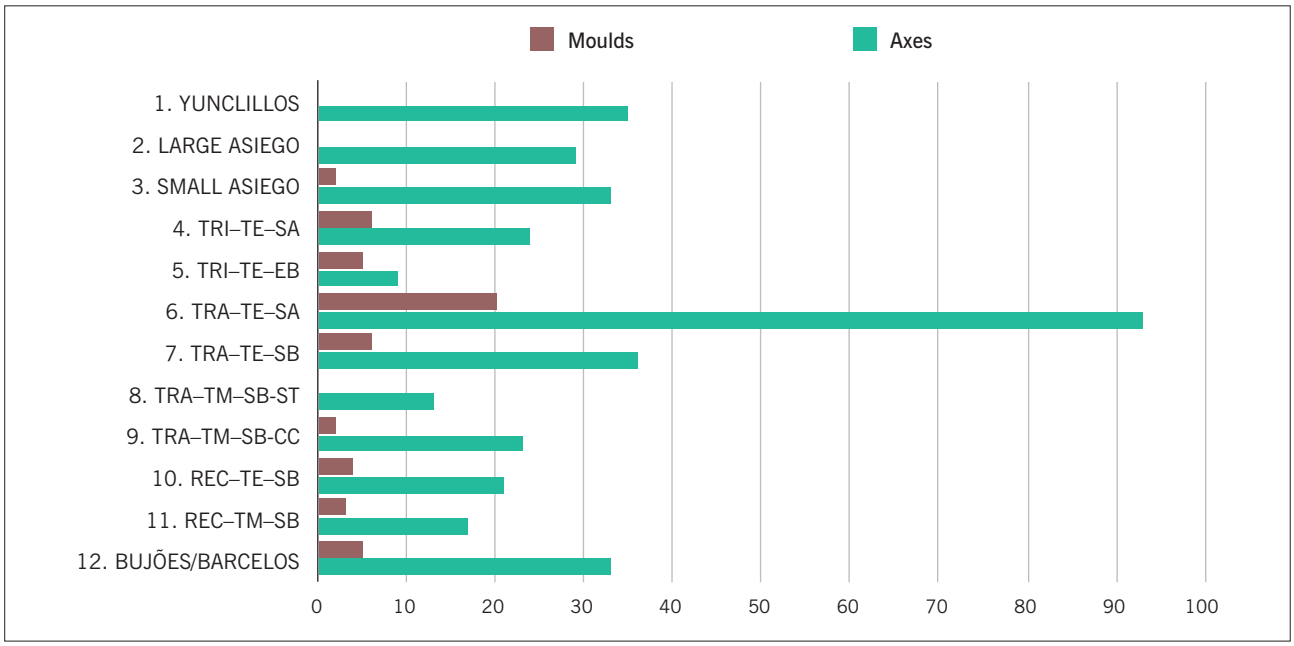


Fig. 21 Comparison of the number of axes and moulds for each taxa.

Abb. 21 *Vergleich der Anzahl von Beilen und Gussformen pro Taxon.*

and between those peripheries[9]. What distinguishes the territories north-east of El Argar is the existence of a notable variety of casting shapes, while the range of taxa in late El Argar is largely restricted to TRA-TE-SA and TRI-TE-SA axes. Only the stout and square shape REC-TE-SB probably started being cast during the final phase of El Argar and its periphery, c. 1650–1550 BC. Not surprisingly, most of these axes were manufactured with tin bronze, sometimes even including notable concentrations of lead.

What distinguishes the Mediterranean regions, including El Argar, from the rest of Iberia and particularly from the Atlantic regions is the small size and light weight of the axeheads produced there. The mean weights of the characteristic Mediterranean taxa range between c. 190–320 g, whereas heavy axe types – with mean weights of 530–830 g – were dominant in Western and Northern Iberia. The Ebro Valley and central Spain (Northern and Southern Meseta) occupied an intermediate position in this respect. It follows that at least twice as many tools or weapons were produced in the Mediterranean than in the rest of Iberia with the same amount of metal. The taxa related to El Argar have a mean length of c. 120 mm (Tab. 11, 12 and 14) and are particularly light. Whereas Small Asiego, with a mean weight of only 190 g, represented the characteristic axes during the Early and Middle El Argar phases (c. 2200–1750 cal BC), the mean weight of the typical Late Argaric TRA-TE-SA and TRI-TE-SA axes increased to 260 g. The fact that the mean length of all other contemporary, heavier taxa was either smaller or only increased up to 145–155 mm implies that the El Argar shapes offered a substantial saving of raw material. In other words, an increase in axe length of only c. 25% required the smelting and casting of twice as much copper in the rest of Iberia. An increase in axe weight also did not lead to a proportional extension of the blade. While the mean cutting edge of the late El Argar taxa was c. 56–59 mm in length, the significantly heavier taxa Bujões/Barcelos, REC-TM-SB, and TRA-TM-SB-CC axes, with a similar chronology, only offered 6–30 % larger blades (dimension B in Tab. 1). The narrow butts, diverging flanges, and slender shapes, distinctive of El Argar but also of other Mediterranean axes, probably required a better or more intense forging to avoid the breakage of these slim artefacts. In sum, according to the present dataset, El Argar metallurgy not only appears as the main producer of axes in the period of 1750–1550 BC, but also as the one mastering the most efficient casting and forging technology.

Apart from the widespread use of tin bronzes, the main change observed in the LBA metallurgy was the production of more stout and square-shaped axes, often with wider butts. This implied a higher requirement of raw material per manufactured unit but probably also much simpler casting and forging processes in comparison to the earlier productions made from arsenic copper. As metals became more accessible to the population, manufacture processes appear to have become simpler.

Conclusions

The morphometric study of 87 stone moulds with 96 matrices and of 367 axeheads from the Iberian Peninsula has

9 Soriano/Amorós 2014; Soriano/Escanilla 2016; Peres/Risch 2022; Peres/Risch 2023.

allowed us to identify twelve productive patterns, defined as taxa, and to establish their temporality according to the available contextual and chronological references. The geographic, chemical, and metric specificity of many of these taxa support their identification with defined productive standards of the Iberian Bronze Age metallurgy.

Up to four EBA taxa could have had their origin in the Bell Beaker period. Their production usually required large amounts of copper (600–1100 g), suggesting an abundance of available raw materials, which is also supported by the Late Copper Age/EBA mining evidence in Iberia. The heaviest of these axes, identified as Yunclillos and Large Asiego, were frequently placed in hoards throughout Iberia. After 2100 BC, at least two more axe taxa appeared. While REC-TM-SB circulated in Central and Northern Iberia, Small Asiego were characteristic of the Early and Middle El Argar phases (c. 2000–1750 BC) in the south. With a mean weight of only c. 190 g, the latter allowed a substantial reduction of raw material likely to be related to the increasing number of axes required by the rapidly expanding El Argar agricultural and political territories (Lull et al. 2011; Delgado Raack/Risch 2015). All six EBA taxa were made from copper, usually containing over 0.5 % arsenic, and three of them could have been cast, at least occasionally, with stone moulds.

The relatively short MBA (c. 1800–1550 BC) emerges, in the present study, as the period of maximum metallurgical development, considering that axes were – by far – the heaviest metal artefacts throughout the Bronze Age. Not only did the manufacture of at least three of the six EBA taxa continue, but another six new shapes where introduced. In the eastern half of Iberia as well as in the north-west, most taxa were cast in stone moulds. In some of these areas, such as in the north-east, the Ebro Valley, and the north-west – the latter with rich tin deposits – the oldest evidence of tin bronze production in the Iberian Peninsula is found (Soriano/Amorós 2014; Aguilera Aragón et al. 2023; Armada et al. 2023). It could be from one or more of these regions that arsenical copper was gradually replaced in the rest of the peninsula by true tin bronze.

El Argar metallurgy specialised in the production of light and very slim axes with narrow butts (TRA-TE-SA and TRI-TE-SA taxa). The spatial distribution of casting matrices and axes reveals that the same axes were also produced beyond the El Argar territory, along the Mediterranean, up to the north-east (Catalunya), providing further evidence of the far-reaching relations between El Argar and other regions of the Iberian Peninsula, as has recently also been suggested based on lead isotope analysis of El Argar metals (Murillo-Barroso et al. 2024). The production of such slim axes with narrow butts and diverging flanges must have required exceptional casting skills. Experimental tests would be required to prove whether such artefacts would be resistant enough to be used as wood working tools. Their use as weapons is highly likely in view of their presence in a certain class of El Argar male burials (cf. Bonora Soriano in this volume) and their serial production with stone moulds. In terms of the absolute number of both artefacts and casting matrices, the typical Argaric TRA-TE-SA axes must have been the main metal product of MBA Iberia and the main destination of metal resources. Economic, demographic, and military factors were the possible causes behind this relatively brief metallurgical take-off.

The LBA continues to be an insufficiently understood period of prehistoric Iberia largely due to the limited settlement and funerary evidence, especially in the southern and western part of Iberia (Lull et al. 2013; Iacono et al. 2021). However, a notable number of hoards and single finds as well as the widespread use of tin bronze suggest a dynamic production and circulation of metals. At least nine different taxa were manufactured during the LBA, four of which appear to have been specific to this period (Fig. 20). Most of them correspond to stout shapes with a low symmetry (SB) and slenderness (EB). The production of such compact and, consequently, more resistant axes required a higher amount metal, but probably less forging skill. Better access to raw materials is also indicated by the increase in weight of most LBA taxa. Only small axes, with a mean length of only c. 100 mm and manufactured with widely diverging flanges (TRI-TE-EB), required a similar amount of metal than the equivalent, notably slenderer El Argar axes (TRI-TE-SA).

This new axe classification has provided better insight into the development of Bronze Age metallurgy of the Iberian Peninsula. These results will be refined as better dating evidence becomes available. The combination of the axe taxa with chemical data and their spatial distribution is the next step in this research line. It will allow researchers to identify the axe production centres and the networks through which they circulated. Finally, lead isotopes need to be measured in order to determine, always in combination with chemical analyses, the provenance of the raw materials of each morphometric taxon.

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2	M. Peres, R. Risch, and see Annex 1
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Annex 1

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H001	Donana	Treviño	Burgos	NM	TRI-TE-SA		Monteagudo 1977, No. 624A; Fig. 34; Rodríguez de la Esperanza 2005
H002	Las Cogotas	Cardeñosa	Ávila	NM	TRA-TM-SB-CC-var		Monteagudo 1977, No. 705; Fig. 40; Herrán Martínez 2008, 20; Fig. 3,1
H003	El Otero_MN	Valdevimbre	León	NM	REC-TE-SB		Monteagudo 1977, No. 607; Fig. 33; Fig. 149 B; Celis et al. 2007; Herrán Martínez 2008, 80; Fig. 51,5
H004	El Otero_MN	Valdevimbre	León	NM	TRA-TM-SB-ST-var		Monteagudo 1977, No. 625; Fig. 34; Fig. 149 B; Herrán Martínez 2008, 79; Fig. 51,7
H005	Indet	León province	León	NM	TRI-TE-EB		Delibes de Castro et al. 1999a, 44–45; Fig. 14,37
H006	Indet	León province	León	NM	TRA-TE-SB		Monteagudo 1977, No. 616; Fig. 33; Delibes de Castro et al. 1999a, 44–45; Fig. 14,38
H007	Villaceid	Villaceid	León	NM	TRI-TE-EB		Monteagudo 1977, No. 613; Fig. 33; Herrán Martínez 2008; 81; Fig. 52,4
H008	Indet	León or Palencia province	León or Palencia	NM	TRA-TE-SB		Delibes de Castro et al. 1999a, 44–45; Fig. 14,32
H009	Indet	León or Palencia province	León or Palencia	NM	TRA-TM-SB-CC		Delibes de Castro et al. 1999a, 44–45; Fig. 14,39
H010	Carrión de los Condes	Carrión de los Condes	Palencia	NM	TRA-TE-SB		Monteagudo 1977, No. 622; Fig. 34; Delibes de Castro et al. 1999a, 44–45; Fig. 14,34
H011	Carrión de los Condes	Carrión de los Condes	Palencia	NM	TRA-TE-SB		Monteagudo 1977, No. 621; Fig. 33; Delibes de Castro et al. 1999a; 44–45; Fig. 14,35
H012	Dueñas	Dueñas	Palencia	NM	Bujões/Barcelos		Monteagudo 1977, No. 623; Fig. 34; Herrán Martínez 2008, 100; Fig. 68,3; Delibes de Castro et al. 1999a, 44–45; Fig. 14,33; Gener et al. 2009
H013	Las Tuerces	Villaescusas de las Torres	Palencia	NM	REC-TE-SB		Herrán Martínez 2008; 113; Fig. 76,5; Alcalde Crespo 1990
H014	Cueva del Arevalillo	Arevalillo de Cega	Segovia	NM	TRA-TE-SB		Herrán Martínez 2008, 132; Fig. 89,1; Delibes de Castro et al. 1999
H015	Cueva de Los Huesos	Pedraza	Segovia	NM	TRI-TE-SA		Herrán Martínez 2008, 133; Fig. 90,5; Delibes de Castro et al. 1999
H016	Los Tolmos	Caracena	Soria	NM	TRA-TE-SB	c. 1850–1520 BC	Herrán Martínez 2008, 139; Fig. 94,1; Delibes de Castro et al. 1999, Fig. 3
H017	Cerro de El Cuchillo	Almansa	Albacete	SM	TRA-TE-SB	c. 1950–1705 BC	Hernández Pérez et al. 1994, 163–164; Fig. 112,1
H018	Cerro de El Cuchillo	Almansa	Albacete	SM	TRA-TE-SA	c. 1875–1548 BC (I-17445 = 3410–90 BP)	Hernández Pérez et al. 1994, 163–164; Fig. 67,1
H019	El Acequión	Albacete	Albacete	SM	TRA-TE-SB	c. 2100–2050 BC CSIC-829 = 3690–55 BP)	Martín Morales/Benítez de Lugo Enrich 2023, 42; Fig. 20; Benítez de Lugo Enrich 2023; Rovira Llorens/Gómez Ramos 2003, 21

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H020	El Acequión	Albacete	Albacete	SM	TRA-TE-SA	c. 2100–2050 BC (CSIC-829=3690–55 BP)	Martín Morales/Benítez de Lugo Enrich 2023, 43; Fig. 21; Benítez de Lugo Enrich 2023; Rovira Llorens/Gómez Ramos 2003, 21
H021	El Acequión	Albacete	Albacete	SM	REC-TM-SB	c. 2100–2050 BC (CSIC-829=3690–55 BP)	Martín Morales/Benítez de Lugo Enrich 2023, 44; Fig. 22; Benítez de Lugo Enrich 2023; Rovira Llorens/Gómez Ramos 2003, 21
H022	Alconchel de Estrella	Alconchel de Estrella	Cuenca	SM	TRA-TE-SB		Díaz-Andreu García/Montero Ruiz 1998, 33–35; Fig. 6,1
H023	Peña de los Ramos	Boniches	Cuenca	SM	TRI-TE-SA		Díaz-Andreu García/Montero Ruiz 1998, 36–37; Fig. 7
H024	Torrijos	Torrijos	Toledo	SM	Large Asiego		Monteagudo 1977, No. 634; Fig. 34
H025	Gardálegui	Gardálegui	Álava	N	REC-TE-SB		Monteagudo 1977, No. 649; Fig. 35; Rodríguez de la Esperanza 2005
H026	Indet	Víllodas-Trespuentes	Álava	N	Small Asiego		Rodríguez de la Esperanza 2005, Fig. 5,25.3; Gener et al. 2009
H027	Iruzubieta	Marquina	Vizcaya	N	TRA-TE-SA		Monteagudo 1977, No. 608; Fig. 33; Apellániz Castroviejo 1966
H028	Los Cotorros	Basigorta	Vizcaya	N	TRI-TE-SA		Monteagudo 1977, No. 204; Fig. 11
H029	Marquina	Marquina	Vizcaya	N	TRA-TE-SA		Monteagudo 1977, No. 609; Fig. 33
H030	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 184; Fig. 9; Blas Cortina 1999; Reguera-Galán et al. 2019
H031	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 194; Fig. 10; Blas Cortina 1999; 2011; Reguera-Galán et al. 2019
H032	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 195; Fig. 10; Blas Cortina 1999; 2011; Reguera-Galán et al. 2019
H033	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 196; Fig. 10; Blas Cortina 1999; 2011; Reguera-Galán et al. 2019
H034	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 197; Fig. 10; Blas Cortina 1999; 2011; Reguera-Galán et al. 2019
H035	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 198; Fig. 11; Blas Cortina 1999; 2011; Reguera-Galán et al. 2019
H036	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 199; Fig. 11; Blas Cortina 1999; 2011
H037	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 185; Fig. 9; Blas Cortina 1999; 2011
H038	Asiego	Cabrales	Asturias	N	Large Asiego-var		Monteagudo 1977, No. 186; Fig. 10; Blas Cortina 1999; 2011; Reguera-Galán et al. 2019
H039	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 187; Fig. 10; Blas Cortina 1999; 2011; Reguera-Galán et al. 2019

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H040	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 189; Fig. 10; Blas Cortina 1999; 2011
H041	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 190; Fig. 10; Blas Cortina 1999; 2011; Reguera-Galán et al. 2019
H042	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 191; Fig. 10; Blas Cortina 1999; 2011
H043	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 192; Fig. 10; Blas Cortina 1999; 2011; Reguera-Galán et al. 2019
H044	Asiego	Cabrales	Asturias	N	Large Asiego		Monteagudo 1977, No. 193; Fig. 10; Blas Cortina 1999; 2011; Reguera-Galán et al. 2019
H045	Box	Oviedo	Asturias	N	Bujões/Barcelos		Monteagudo 1977, No. 780; Fig. 47; Blas Cortina 1999
H046	Cangas de Narcea	Cangas de Narcea	Asturias	N	Small Asiego-var		Monteagudo 1977, No. 657; Fig. 35; Comendador Rey 1997; 243
H047	El Milagro	Cangues d'Onís	Asturias	N	TRA-TM-SB-ST		Monteagudo 1977, No. 683A; Fig. 38; Blas Cortina 1999; Comendador Rey 1997, 180A
H048	Figares	Salas	Asturias	N	Bujões/Barcelos		Monteagudo 1977, No. 763A; Fig. 157; Blas Cortina 1999
H049	Fuente de Frieras	Posada de Llanes	Asturias	N	REC-TM-SB		Monteagudo 1977, No. 682; Fig. 37; Blas Cortina 1999; 2011
H050	Fuente de Frieras	Posada de Llanes	Asturias	N	REC-TM-SB		Monteagudo 1977, No. 712; Fig. 41; Blas Cortina 1999; 2011
H051	Fuente de Frieras	Posada de Llanes	Asturias	N	TRA-TM-SB-CC		Monteagudo 1977, No. 713; Fig. 41; Blas Cortina 1999; 2011
H052	Fuente de Frieras	Posada de Llanes	Asturias	N	REC-TE-SB		Monteagudo 1977, No. 727; Fig. 42; Blas Cortina 1999; 2011
H053	Gueraño/Llano del Con	Cangues d'Onís	Asturias	N	Large Asiego		Monteagudo 1977, No. 181; Fig. 9; Comendador Rey 1997, 256; Reguera-Galán et al. 2019
H054	Los Fitos	Puerto de la Cobertoria	Asturias	N	TRA-TE-SB		Blas Cortina 1999, Fig. 7,9; Rovira Llorens/Gómez Ramos 2003, 137
H055	Mieres	Mieres	Asturias	N	TRA-TE-SB		Monteagudo 1977, No. 201; Fig. 11; Blas Cortina 1999
H056	Muniellos	Cangas de Narcea	Asturias	N	TRA-TE-SB		Monteagudo 1977, No. 775; Fig. 46; Blas Cortina 1999
H057	Oviedo?	Oviedo?	Asturias	N	Bujões/Barcelos		Monteagudo 1977, No. 714; Fig. 41; Blas Cortina 1999; Delibes de Castro et al. 1999a, 44–45; Fig. 14,41
H058	Santianes	Zardón	Asturias	N	Bujões/Barcelos		Monteagudo 1977, No. 764; Fig. 45; Blas Cortina 1999
H059	Villoria	Villoria	Asturias	N	Large Asiego		Monteagudo 1977, No. 182; Fig. 9; Comendador Rey 1997, 248
H060	Cueva de los Hornucos	Suano	Cantabria	N	TRA-TE-SB		Monteagudo 1977, No. 624; Fig. 34; Blas Cortina 1999

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H061	Puente de la Maza	San Vicente de la Barquera	Cantabria	N	REC-TM-SB		Monteagudo 1977, No. 685; Fig. 38; Blas Cortina 1999
H062	Tina Mayor	Liébana	Cantabria	N	REC-TM-SB		Monteagudo 1977, No. 684; Fig. 38; Blas Cortina 1999
H063	Balma dels Ossos de la Torre d'en Cornet	Sallent	Barcelona	NE	Small Asiego-var		Martín Cólliga et al. 1999, 137; Fig. 5,4; Soriano 2013, 91–96
H064	Roc d'en Sardinyà	Vilassar de Dalt	Barcelona	NE	TRA-TE-SA		Monteagudo 1977, No. 566C; Fig. 30; Soriano 2013, 91–96
H065	Castell d'Aro	Castell d'Aro	Girona	NE	Small Asiego-var		Monteagudo 1977, No. 566E; Fig. 30; Soriano 2013, 91–96
H066	Girona	Girona	Girona	NE	TRI-TE-EB		Monteagudo 1977, No. 566D; Fig. 30; Soriano 2013, 91–96
H067	Las Valletas/Indet	Sena/Indet	Huesca/Zaragoza	EV	Small Asiego		Rodríguez de la Esperanza 2005; Fig. 5,25.1; Monteagudo 1977, No. 651; Fig. 35
H068	Puerto de San Andrés	San Millán de la Cogolla	La Rioja	EV	Bujões/Barcelos		Photo by V. Schulmeister Guillén, MAN for CER.es, http://ceres.mcu.es, MCD, Spain; Rovira Llorens et al. 1997, 246
H069	Alfarràs	Alfarràs	Lleida	NE	TRA-TM-SB-ST		Martín Cólliga et al. 1999, 137; Fig. 5,2; Moya 1997; Soriano 2013, 91–96
H070	Cova dels Canals	Pinyana	Lleida	NE	TRA-TE-SA		Monteagudo 1977, No. 551; Fig. 29; Soriano 2013, 91–96
H071	Lleida	Lleida	Lleida	NE	Bujões/Barcelos-var		Monteagudo 1977, No. 552; Fig. 29; Soriano 2013, 91–96
H072	Navarra	Navarra	Navarra	EV	Small Asiego		Monteagudo 1977, No. 570; Fig. 30; Maluquer de Motes 1952
H073	Navarra	Navarra	Navarra	EV	Small Asiego		Monteagudo 1977, No. 571; Fig. 30; Maluquer de Motes 1952
H074	Navarra	Navarra	Navarra	EV	Small Asiego		Monteagudo 1977, No. 572; Fig. 30; Maluquer de Motes 1952
H075	Navarra?	Navarra?	Navarra?	EV	TRA-TE-SB		Monteagudo 1977, No. 731; Fig. 42
H076	Camp de Tarragona	Camp de Tarragona	Tarragona	NE	REC-TE-SB		Monteagudo 1977, No. 610; Fig. 33; Soriano 2013, 91–96
H077	Cova Josefina	Riudecanyes	Tarragona	NE	TRA-TM-SB-ST		Monteagudo 1977, No. 208; Fig. 11; Soriano 2013, 91–96; Montero Ruiz 2017
H078	Cabezo Cariñena	Ariño	Teruel	EV	TRA-TE-SA		Rovira Llorens et al. 1997, 372; Fig. 36; Rodríguez de la Esperanza 2005
H079	Partida de las Naves	Alloza	Teruel	EV	TRA-TE-SB		Monteagudo 1977, No. 466A; Fig. 25; Rodríguez de la Esperanza 2005
H080	Majaladares (exterior)	Borja	Zaragoza	EV	TRA-TM-SB-ST	c. 1900–1700 BC	Aguilera Aragón 2022, 285; Fig. 14,7; Rodríguez de la Esperanza 2005

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H081	Zuera	Zuera	Zaragoza	EV	TRI-TE-SA		Rodríguez de la Esperanza 2005, 94; Fig. 5,25.7
H082	Fisterra?	Fisterra?	A Coruña	NW	Bujões/Barcelos		Monteagudo 1977, No. 748; Fig. 44; Bettencourt/ Comendador Rey 2004
H083	A Coruña?	A Coruña?	A Coruña?	NW	Small Asiego-var		Monteagudo 1977, No. 568; Fig. 30; Suárez Otero 2016
H084	Póvoa de Varzím?	Póvoa de Varzím?	Douro Litoral	NW	Bujões/Barcelos		Monteagudo 1977, No. 757A; Fig. 45; Bettencourt/ Comendador Rey 2004
H085	Lugo?	Lugo?	Lugo?	NW	Bujões/Barcelos		Monteagudo 1977, No. 763; Fig. 45; Bettencourt/ Comendador Rey 2004
H086	Bandeira	Viana do Castelo	Minho	NW	Bujões/Barcelos		Oliveira Fernandes et al. 2011, 36; Fig. 3
H087	Felgueiras	Guimarães	Minho	NW	Bujões/Barcelos		Monteagudo 1977, No. 756; Fig. 44; Bettencourt/ Comendador Rey 2004; Senna-Martinez et al. 2013
H088	Gonça	Guimarães	Minho	NW	Bujões/Barcelos		Monteagudo 1977, No. 757; Fig. 45; Bettencourt/ Comendador Rey 2004; Senna-Martinez et al. 2013
H089	Mina Folgadoura	Viana do Castelo	Minho	NW	Bujões/Barcelos		Monteagudo 1977, No. 739; Fig. 43; Bettencourt/ Comendador Rey 2004
H090	Monte de Choriz	Gondomar	Minho	NW	Bujões/Barcelos		Monteagudo 1977, No. 736A; Fig. 43; Bettencourt/ Comendador Rey 2004
H091	Santo Ovídio	Ponte do Lima	Minho	NW	Bujões/Barcelos		Monteagudo 1977, No. 740; Fig. 43; Bettencourt/ Comendador Rey 2004; Bottaini et al. 2012
H092	São João de Rei	Póvoa de Lanhoso	Minho	NW	TRA-TM-SB-CC		Monteagudo 1977, No. 726; Fig. 42; Bottaini et al. 2012
H093	Valença do Minho	Valença do Minho	Minho	NW	Bujões/Barcelos		Monteagudo 1977, No. 743; Fig. 43; Bettencourt/ Comendador Rey 2004
H094	Cerdeiras	Forcas	Ourense	NW	Bujões/Barcelos		Monteagudo 1977, No. 735; Fig. 43; Bettencourt/ Comendador Rey 2004
H095	Ourense	Ourense	Ourense	NW	Bujões/Barcelos		Monteagudo 1977, No. 725; Fig. 42; Bettencourt/ Comendador Rey 2004
H096	Camposancos	Pontevedra	Pontevedra	NW	Bujões/Barcelos		Monteagudo 1977, No. 742; Fig. 43; Bettencourt/ Comendador Rey 2004
H097	Camposancos	Pontevedra	Pontevedra	NW	Bujões/Barcelos		Monteagudo 1977, No. 750; Fig. 44; Bettencourt/ Comendador Rey 2004
H098	Codeseda	A Estrada	Pontevedra	NW	Large Asiego-var		Monteagudo 1977, No. 745; Fig. 44; Bettencourt/ Comendador Rey 2004
H099	Codeseda	A Estrada	Pontevedra	NW	Bujões/Barcelos		Monteagudo 1977, No. 761; Fig. 45; Bettencourt/ Comendador Rey 2004
H100	Monte do Castro	Vigo	Pontevedra	NW	Bujões/Barcelos		Monteagudo 1977, No. 606; Fig. 33; Bettencourt/ Comendador Rey 2004; Suárez Otero 2016
H101	Portas	Pontevedra	Pontevedra	NW	Bujões/Barcelos		Monteagudo 1977, No. 744; Fig. 44; Bettencourt/ Comendador Rey 2004

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H102	Indet	Pontevedra province	Pontevedra	NW	REC-TE-SB		Monteagudo 1977, No. 752; Fig. 44; Delibes de Castro et al. 1999a, 44–45; Fig. 14,40; Gener et al. 2009
H103	Tomiño-A Guarda	Rosal	Pontevedra	NW	Bujões/Barcelos		Monteagudo 1977, No. 759; Fig. 45; Bettencourt/ Comendador Rey 2004
H104	Agro Velho	Montalegre	Trás-Os-Montes	NW	Bujões/Barcelos		Monteagudo 1977, No. 717; Fig. 41; Bettencourt/ Comendador Rey 2004
H105	Agro Velho	Montalegre	Trás-Os-Montes	NW	Bujões/Barcelos		Monteagudo 1977, No. 718; Fig. 41; Bettencourt/ Comendador Rey 2004
H106	Bujões	Abaças	Trás-Os-Montes	NW	TRA-TM-SB-CC		Monteagudo 1977, No. 706; Fig. 40; Senna-Martinez et al. 2013
H107	Bujões	Abaças	Trás-Os-Montes	NW	TRA-TM-SB-CC		Monteagudo 1977, No. 708; Fig. 40; Senna-Martinez et al. 2013
H108	Cervos/Gralhós	Montalegre	Trás-Os-Montes	NW	TRA-TM-SB-CC-var		Monteagudo 1977, No. 709; Fig. 40; Bettencourt/ Comendador Rey 2004
H109	Fervidas	Montalegre	Trás-Os-Montes	NW	Bujões/Barcelos		Monteagudo 1977, No. 722; Fig. 42; Bettencourt/ Comendador Rey 2004
H110	Vimioso	Vimioso	Trás-Os-Montes	NW	Large Asiego		Monteagudo 1977, No. 180; Fig. 9; Comendador Rey 1997, 237
H111	Fraga da Pitorca	S. António de Monforte, Vila Real	Trás-Os-Montes	NW	TRA-TM-SB-CC		Comendador Rey 1997; 123–124; Fig. 8,2
H135	Arrabalde	Huerta de Pozancos	Huelva	SW	TRA-TE-SB		Schubart 1975, Fig. 44,492
H136	Rio Tinto	Río Tinto	Huelva	SW	TRA-TM-SB-CC		Schubart 1975, Fig. 44,518; Hunt Ortiz 2003, 334; Fig. 140,3
H137	Indet	Beja	Baixo Alentejo	SW	Small Asiego		Schubart 1975, Fig. 45,362; Monteagudo 1977, No. 641; Fig. 35
H138	Beja	Beja	Baixo Alentejo	SW	Large Asiego		Schubart 1975, Fig. 45,363; Monteagudo 1977, No. 623; Fig. 34
H140	Évora	Évora	Alto Alentejo	SW	Small Asiego-var		Schubart 1975, Fig. 45,466; Monteagudo 1977, No. 633; Fig. 34
H141	Évora	Évora	Alto Alentejo	SW	Large Asiego		Schubart 1975, Fig. 45,475; Monteagudo 1977, No. 382; Fig. 22
H142	Outeiro Leido?	Outeiro Leido?	Alto Alentejo	SW	Small Asiego		Schubart 1975, Fig. 45,488; Monteagudo 1977, No. 646; Fig. 35
H143	Algarve	Algarve	Algarve	SW	Large Asiego		Schubart 1975, Fig. 46,003
H144	Aljezur	Aljezur	Algarve	SW	REC-TE-SB		Schubart 1975, Fig. 46,007; Monteagudo 1977, No. 640; Fig. 35
H145	Monchique	Monchique	Algarve	SW	Small Asiego-var		Schubart 1975, Fig. 46,051; Monteagudo 1977, No. 639; Fig. 35

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H146	São Salvador	Odemira	Baixo Alentejo	SW	Large Asiego		Schubart 1975, Fig. 46,184; Monteagudo 1977, No. 629; Fig. 34
H147	Santa Cruz	Santiago do Cacem	Baixo Alentejo	SW	Large Asiego		Schubart 1975, Fig. 46,418; Monteagudo 1977, No. 631; Fig. 34; Soares et al. 2016
H148	Évora	Évora	Alto Alentejo	SW	TRI-TE-SA		Schubart 1975, Fig. 46,463
H149	Campos de Grândola	Grândola	Alto Alentejo	SW	TRA-TM-SB-CC		Schubart 1975, Fig. 47,423; Monteagudo 1977, No. 693; Fig. 39
H151	Cascalheira e Casinha, Evora	Évora	Alto Alentejo	SW	TRA-TM-SB-CC		Schubart 1975, Fig. 47,462; Monteagudo 1977, No. 672; Fig. 37
H152	Évora	Évora	Alto Alentejo	SW	TRA-TM-SB-CC		Schubart 1975, Fig. 47,464; Monteagudo; 1977, No. 694; Fig. 39
H153	Agramaça (Conc. Beja?)	Beja?	Baixo Alentejo	SW	REC-TM-SB-var		Schubart 1975, Fig. 48,359; Monteagudo 1977, No. 598; Fig. 32
H154	Mina da Juliana	Beja	Baixo Alentejo	SW	TRA-TM-SB-CC		Schubart 1975, Fig. 48,373; Monteagudo 1977, No. 690; Fig. 38
H155	Mina da Juliana	Beja	Baixo Alentejo	SW	TRA-TM-SB-CC		Schubart 1975, Fig. 48,374; Monteagudo 1977, No. 689; Fig. 38
H156	Santa Cruz	Santiago do Cacém	Baixo Alentejo	SW	TRA-TE-SB		Schubart 1975, Fig. 48,419; Monteagudo 1977, No. 599; Fig. 32; Soares et al. 2016
H157	Portel	Portel	Baixo Alentejo	SW	REC-TE-SB		Schubart 1975, Fig. 48,448; Monteagudo 1977, No. 515; Fig. 27
H158	Cascalheira e Casinha, Évora	Évora	Alto Alentejo	SW	TRA-TE-SB		Schubart 1975, Fig. 48,461; Monteagudo 1977, No. 600A; Fig. 28
H159	Évora	Évora	Alto Alentejo	SW	TRA-TE-SB		Schubart 1975, Fig. 48,471; Monteagudo 1977, No. 600; Fig. 32
H160	Portimão	Portimão	Algarve	SW	TRA-TM-SB-CC-var		Schubart 1975, Fig. 49,076
H161	Estombar	Lagôa	Algarve	SW	REC-TM-SB		Schubart 1975, Fig. 49,101; Monteagudo 1977, No. 664; Fig. 36
H162	Santiago do Cacém	Santiago do Cacém	Baixo Alentejo	SW	TRA-TM-SB-CC-var		Schubart 1975, Fig. 49,417; Monteagudo 1977, No. 692; Fig. 38
H163	Santa Cruz	Santiago do Cacém	Baixo Alentejo	SW	REC-TE-SB-var		Schubart 1975, Fig. 49,420; Monteagudo 1977, No. 611; Fig. 33; Soares et al. 2016
H164	Évora	Évora	Alto Alentejo	SW	REC-TM-SB		Schubart 1975, Fig. 49,462
H165	Algarve	Algarve	Algarve	SW	TRA-TM-SB-CC		Schubart 1975, Fig. 50,004
H166	São Bartolomeu de Messines	Silves	Algarve	SW	TRA-TE-SB		Schubart 1975, Fig. 50,106; Monteagudo 1977, No. 593; Fig. 32
H167	São Bartolomeu de Messines	Silves	Algarve	SW	REC-TM-SB		Schubart 1975, Fig. 50,107; Monteagudo 1977, No. 324

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H168	Alcácer do Sal	Alcácer do Sal	Baixo Alentejo	SW	TRA-TE-SB		Schubart 1975, Fig. 50,425; Monteagudo 1977, No. 766; Fig. 46
H169	Algarve	Algarve	Algarve	SW	Small Asiego-var		Schubart 1975, Fig. 51,005; Monteagudo 1977, No. 654; Fig. 35
H170	Algarve	Algarve	Algarve	SW	Small Asiego-var		Schubart 1975, Fig. 51,006; Monteagudo 1977, No. 653; Fig. 35
H171	São Bartolomeu de Messines	Silves	Algarve	SW	TRA-TE-SB		Schubart 1975, Fig. 51,108; Monteagudo 1977, No. 405; Fig. 23
H172	Messejana	Aljustrel	Baixo Alentejo	SW	REC-TE-SB		Schubart 1975, Fig. 51,358
H173	Arcos de la Frontera	Arcos de la Frontera	Cádiz	SW	REC-TM-SB		Rovira Llorens et al. 1997, 143; Fig. 11; Hunt Ortiz 2003, 334
H174	Fábrica Euskalduna 1	Villaverde	Madrid	SM	TRA-TM-SB-ST		Monteagudo 1977, No. 361; Fig. 19; Martínez Navarrete 1985, Fig. 54
H175	Fábrica Euskalduna 1	Villaverde	Madrid	SM	Small Asiego		Monteagudo 1977, No. 416; Fig. 23; Martínez Navarrete 1985, Fig. 54
H176	Indet	T.M. Arganda	Madrid	SM	TRI-TE-SA		Monteagudo 1977, No. 56 ; Fig. 3; Martínez Navarrete 1985
H177	Cañada de las Cañas A	Pozuelo de Calatrava	Ciudad Real	SM	Yunclillos		Blanco de la Rubia 1983, Fig. 1a; Ruiz-Taboada et al. 2019
H178	Cañada de las Cañas B	Pozuelo de Calatrava	Ciudad Real	SM	Yunclillos		Blanco de la Rubia 1983, Fig. 1b; Ruiz-Taboada et al. 2019
H179	Cañada de las Cañas C	Pozuelo de Calatrava	Ciudad Real	SM	Yunclillos		Blanco de la Rubia 1983, Fig. 1c; Ruiz-Taboada et al. 2019
H180	Cañada de las Cañas 1 MAN	Pozuelo de Calatrava	Ciudad Real	SM	Yunclillos		Monteagudo 1977, No. 372 ; Fig. 21; Martinez Navarrete 1985, Fig. 192; Ruiz-Taboada et al. 2019
H181	Cañada de las Cañas 2 MAN	Pozuelo de Calatrava	Ciudad Real	SM	Yunclillos		Monteagudo 1977, No. 373 ; Fig. 21; Martínez Navarrete 1985, Fig. 192; Ruiz-Taboada et al. 2019
H182	Cañada de las Cañas (San Isidro Mus.)	Pozuelo de Calatrava	Ciudad Real	SM	Yunclillos		Ruiz-Taboada et al. 2019, Fig. 7
H183	Indet	Indet	Ciudad Real	SM	TRA-TE-SA		Monteagudo 1977, No. 514d; Fig. 156
H184	Cabezo Redondo	Villena	Alicante	L	TRI-TE-SA	c. 1747–1333 BC	Simón García 1998, 84; Fig. 47,1
H185	Cabezo Redondo	Villena	Alicante	L	REC-TE-SB	c. 1747–1333 BC	Simón García 1998, 84; Fig. 47,2
H186	Lloma de Betxí	Paterna	Valencia	L	TRI-TE-SA	c. 2117–1684 BC	Pedro Michó de 1998, Fig. 107,17; Simón García 1998, 156; Fig. 92,3; Peres/Risch 2023, Fig. 2o
H187	Lloma de Betxí	Paterna	Valencia	L	Small Asiego-var	c. 2117–1684 BC	Pedro Michó de 1998, Fig. 74,3; Simón García 1998; Peres/Risch 2023, Fig. 2o
H188	Els Germanells	Rafelbunyol	Valencia	L	TRA-TE-SA		Simón García 1998, 156; Fig. 91,5
H189	Cova de la Penya Banyada	Cocentaina	Alicante	L	TRA-TE-SB		Simón García 1998, 120; Fig. 70,13

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H190	Loma de la Terrera/ Coroneta del Rey	Alberic	Valencia	L	TRA-TE-SB		Simón García 1998, 145; Fig. 86,2
H191	Castellet del Porquet	Ollería	Valencia	L	TRI-TE-SA		Simón García 1998, 135; Fig. 78,17; Monteagudo 1977, No. 522; Fig. 27
H192	Castellet del Porquet	Ollería	Valencia	L	TRI-TE-EB		Simón García 1998, 135; Fig. 78,18; Monteagudo 1977, No. 788; Fig. 47
H194	La Horna	Aspe	Alicante	L	TRI-TE-EB	c. 1750–1300 BC	Simón García 1998, 73; Fig. 42,6
H195	Camí de la Ratlla	Abeller	Castellón	L	TRA-TE-SA		Oliver Foix 2010, Fig. 5
H196	Mas de Menente	Alcoi	Alicante	L	TRA-TE-SA		Simón García 1998, 90; Fig. 65,1; Monteagudo 1977, No. 500; Fig. 26
H197	Coveta del Flare	Xábia	Alicante	L	Small Asiego-var		Simón García 1998, 125; Fig. 74,5
H198	Cova Santa	Font de la Figuera	Valencia	L	TRA-TE-SA		Simón García 1998, 127, Fig. 76,1
H199	Cova Santa	Font de la Figuera	Valencia	L	TRA-TE-SA		Simón García 1998, 127; Fig. 99,4
H200	Cueva de Enguera	Enguera	Valencia	L	TRA-TE-SA		Simón García 1998, 142; Fig. 99,5
H201	Valchica	Ejea de los Caballeros	Zaragoza	EV	Yunclillos		Monteagudo 1977, No. 362; Fig. 20; Ruiz-Taboada et al. 2019
H202	Valchica	Ejea de los Caballeros	Zaragoza	EV	Yunclillos		Monteagudo 1977, No. 363; Fig. 20; Ruiz-Taboada et al. 2019
H203	Valchica	Ejea de los Caballeros	Zaragoza	EV	Yunclillos		Monteagudo 1977, No. 364; Fig. 20; Ruiz-Taboada et al. 2019
H204	Valchica	Ejea de los Caballeros	Zaragoza	EV	Yunclillos		
H205	Valchica	Ejea de los Caballeros	Zaragoza	EV	Yunclillos		Monteagudo 1977, No. 366; Fig. 20; Ruiz-Taboada et al. 2019
H206	Valchica	Ejea de los Caballeros	Zaragoza	EV	Yunclillos		Monteagudo 1977, No. 367; Fig. 20; Ruiz-Taboada et al. 2019
H207	Valchica	Ejea de los Caballeros	Zaragoza	EV	Yunclillos		Monteagudo 1977, No. 368; Fig. 20; Ruiz-Taboada et al. 2019
H208	Valchica	Ejea de los Caballeros	Zaragoza	EV	Yunclillos		Monteagudo 1977, No. 369; Fig. 20; Ruiz-Taboada et al. 2019
H209	Valchica	Ejea de los Caballeros	Zaragoza	EV	Yunclillos		Monteagudo 1977, No. 371; Fig. 21; Ruiz-Taboada et al. 2019
H210	Yunclillos	Yunclillos	Toledo	SM	Yunclillos		Ruiz-Taboada et al. 2019, 58–60; Fig. 2,1
H211	Yunclillos	Yunclillos	Toledo	SM	Yunclillos		Ruiz-Taboada et al. 2019, 58–60; Fig. 2,2
H212	Yunclillos	Yunclillos	Toledo	SM	Yunclillos		Ruiz-Taboada et al. 2019, 58–60; Fig. 2,3
H213	Yunclillos	Yunclillos	Toledo	SM	Yunclillos		Ruiz-Taboada et al. 2019, 58–60; Fig. 2,4
H214	Yunclillos	Yunclillos	Toledo	SM	Yunclillos		Ruiz-Taboada et al. 2019, 58–60; Fig. 2,5

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H215	Yunclillos	Yunclillos	Toledo	SM	Yunclillos		Ruiz-Taboada et al. 2019, 58–60; Fig. 2,6
H216	Yunclillos	Yunclillos	Toledo	SM	Yunclillos		Ruiz-Taboada et al. 2019, 58–60; Fig. 2,7
H217	Cerrocuquillo	Villaluenga de la Sagra	Toledo	SM	Yunclillos		Baquedano Beltrán et al. 2007, Fig. 8; Ruiz-Taboada et al. 2019
H218	Mieres	Mieres	Asturias	N	Yunclillos		Monteagudo 1977, No. 370; Fig. 21; Junghans et al. 1968, No. 2209; Blas Cortina 1999; Ruiz-Taboada et al. 2019
H219	Indet (Sanguino)	Toledo	Toledo	SM	Yunclillos		Ruiz-Taboada et al. 2019, 66; Fig. 9,5
H220	Gamonedo	Gamonedo de Cangas	Asturias	N	TRA-TE-SB		Blas Cortina 1980, Fig. 3,1; Gómez Ramos 1993; Reguera-Galán et al. 2019
H221	Castillo de Frías	Frías de Albarracín	Teruel	EV	Small Asiego-var	c. 1960–1900 BC	Harrison et al. 1998, Fig. 7,7; Fig. 7,9
H222	Cerrocuquillo	Villaluenga de la Sagra	Toledo	SM	Yunclillos		Baquedano Beltrán et al. 2007, Fig. 8; Ruiz-Taboada et al. 2019
H223	Cerro de la Reiná	Alcalá de Jucar	Albacete	SM	TRA-TE-SA		Photo by B. Gamo Parras, Museum of Albacete; Gil Cebrían 2016, Fig. 2,3; Rovira Llorens et al. 1997, 23
H227	El Argar	Antas	Almería	SE	TRA-TE-SA		Schubart/Ulreich 1991, No. 342; Monteagudo 1977, No. 537; Fig. 28,C1; Fig. 146; Montero Ruiz 1991, 205–216
H228	El Argar T245	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 47,245; Monteagudo 1977, No. 537; Fig. 28,C1; Fig. 146; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H229	El Argar T387	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,387; Monteagudo 1977, No. 478; Fig. 25,H1; Fig. 144; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H230	El Argar T725	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 32,725; Monteagudo 1977, No. 532; Fig. 27,A4; Fig. 146; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H231	El Argar T212	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,212; Monteagudo 1977, No. 519; Fig. 27,C1; Fig. 145; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H232	El Argar T479	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 30,479; Monteagudo 1977, No. 463; Fig. 25,A1; Fig. 144; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H233	El Argar T035	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,35; Monteagudo 1977, No. 476; Fig. 25,C1; Fig. 144; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H234	El Argar T816	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Monteagudo 1977, No. 518; Fig. 27; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H235	El Argar T605	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 31,605; Monteagudo 1977, No. 490; Fig. 26; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H236	El Argar T021	Antas	Almería	SE	TRI-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 32,21; Monteagudo 1977, No. 485; Fig. 26,L2; Fig. 144; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H237	El Argar T026	Antas	Almería	SE	TRI-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,26; Monteagudo 1977, No. 491; Fig. 26; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H238	El Argar T276	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,276; Monteagudo 1977, No. 488; Fig. 26; Montero Ruiz 1991, 205–216
H239	La Bastida T1	Totana	Murcia	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Lull et al. 2015c, Annex 1,301; Fig. 3; Lull et al. 2018, Tab. 3
H240	El Argar T609	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 31,609; Monteagudo; 1977, No. 499; Fig. 26; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H241	El Argar T400	Antas	Almería	SE	TRI-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 30,400; Monteagudo 1977, No. 526; Fig. 27,F1; Fig. 145; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H242	El Argar T813	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Monteagudo 1977, No. 540A; Fig. 28; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H243	El Argar T307	Antas	Almería	SE	TRI-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,307; Monteagudo 1977, No. 480; Fig. 25,K3; Fig. 144; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H244	El Argar	Antas	Almería	SE	TRA-TE-SA		Siret/Siret 1890, Fig. 26,8?
H245	Laderas del Castillo	Callosa	Alicante	L	TRA-TE-SA		Simón García 1998, 30; Fig. 15,4; Monteagudo 1977, No. 502; Fig. 26; Lull et al. 2018, Tab. 3
H246	Laderas del Castillo	Callosa	Alicante	L	Small Asiego		Simón García 1998, 30; Fig. 15,1
H247	Laderas del Castillo	Callosa	Alicante	L	Small Asiego		Simón García 1998, 30; Fig. 15,2
H248	Laderas del Castillo	Callosa	Alicante	L	TRA-TE-SA		Simón García 1998, 30; Fig. 16,1; Monteagudo 1977, No. 501; Fig. 26
H249	Laderas del Castillo	Callosa	Alicante	L	TRA-TE-SA		Simón García 1998, 30; Fig. 16,2; Monteagudo 1977, No. 457; Fig. 25; Lull et al. 2018, Tab. 3
H250	San Antón	Orihuela	Alicante	L	TRA-TE-SA		Simón García 1998, 17; Fig. 5,1; Brandherm et al. 2022
H251	San Antón	Orihuela	Alicante	L	TRA-TE-SA		Simón García 1998, 17; Fig. 5,3
H252	Fuente Álamo	Cuevas de Almanzora	Almería	SE	TRA-TE-SA		Pingel et al. 1998, Fig. 15
H253	Fuente Álamo T068	Cuevas de Almanzora	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Schubart 2012, Fig. 35; Montero Ruiz 1991, 227–232; Stos-Gale et al. 1999; OXALID Database; Murillo-Barroso et al. 2015; Lull et al. 2018, Tab. 3
H254	Villalobos	Alcalá la Real	Jaén	SE	REC-TE-SB		Carrasco et al. 1980, Fig. 27,2
H255	Villalobos	Alcalá la Real	Jaén	SE	TRI-TE-SA		Carrasco et al. 1980, Fig. 27,7
H256	Castillo de Locubin	Alcalá la Real	Jaén	SE	TRA-TE-SA		Carrasco et al. 1980, Fig. 27,9

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H257	Corral de los Quiñones	Quesada	Jaén	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Carrasco et al. 1980, Fig. 27,2
H258	Corral de los Quiñones	Quesada	Jaén	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Carrasco et al. 1980, Fig. 22,5
H259	Arjona	Arjona	Jaén	SE	REC-TM-SB-var		Monteagudo 1977, No. 354; Fig. 19; Carrasco et al. 1980, Fig. 23,1
H260	Arjona	Arjona	Jaén	SE	REC-TE-SB		Monteagudo 1977, No. 652; Fig. 35; Carrasco et al. 1980; Fig. 23,2
H261	Cerro Negro de Ugéjar	Lorca	Murcia	SE	TRA-TE-SA		Photo/drawing by C. Garrido García, UAB; Montero Fenollós et al. 2014, Fig. 5
H262	Cerro Negro de Ugéjar	Lorca	Murcia	SE	Small Asiego-var		Photo/drawing by C. Garrido García, UAB; Montero Fenollós et al. 2014, Fig. 4
H263	Madres Mercedarias T017	Lorca	Murcia	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Photo/drawing by C. Garrido García, UAB; Montero Fenollós et al. 2014, Fig. 18; Lull et al. 2018, Tab. 3
H265	Terrera del Reloj	Dehesas de Guadix	Granada	SE	TRA-TE-SA		Aguayo de Hoyos/Contreras Cortés 1981, 281; Fig. 17e; Bashore Acero 2013
H267	Terrera del Reloj T002?	Dehesas de Guadix	Granada	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Photo by I. de la Torre Castellano, M. Arq. Etnol. Granada for CER.es; http://ceres.mcu.es; MCD, Spain; Montero Ruiz 1991, 308–310; Bashore Acero 2013; Lull et al. 2018, Tab. 3
H268	Cerro de la Encina T018	Monachil	Granada	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Murillo–Barroso et al. 2015, Fig. 5i; Lull et al. 2018, Tab. 3
H269	Aracena	Aracena	Huelva	SW	TRA-TE-SA		Hunt Ortiz 2003, 334; Fig. 140,1
H270	Sierra de Baños	Almonaster	Huelva	SW	REC-TM-SB		Harrison/Craddock 1981, Fig. 5,26; Hunt Ortiz 2003, 334; Fig. 140,2
H271	Manzanilla	Manzanilla	Huelva	SW	Small Asiego		Hunt Ortiz 2003, 334; Fig. 140,4; Gómez Ramos et al. 1999
H272	Cádiz	Cádiz	Huelva	SW	TRA-TE-SA		Harrison/Craddock 1981, Fig. 4,22; Hunt Ortiz 2003, 334; Fig. 140,5
H273	Indet	Sevilla province	Sevilla	SW	Small Asiego-var		Harrison/Craddock 1981, Fig. 4,18; Hunt Ortiz 2003, 334; Fig. 140,6
H274	Majaladares (exterior)	Borja	Zaragoza	EV	REC-TM-SB	c. 1900–1700 BC	Aguilera Aragón 2022, 285; Fig. 14,7
H275	La Mesa	Alcalá la Real	Jaén	SE	Large Asiego-var		López Rey 1994, Fig. 2
H276	Sierra Leones	Priego	Córdoba	SW	TRA-TE-SB-var		López Rey 1994, Fig. 2
H277	Cerro del Ahorcado	Puente Genil	Córdoba	SW	Yunclillos		Martínez Rodríguez 1990, Fig. 2; Arteaga Matute 2014
H278	Cerro del Ahorcado	Puente Genil	Córdoba	SW	Yunclillos		Martínez Rodríguez 1990, Fig. 2; Arteaga Matute 2014
H279	Cerro del Ahorcado	Puente Genil	Córdoba	SW	Yunclillos		Martínez Rodríguez 1990, Fig. 2; Arteaga Matute 2014
H280	Cerro del Ahorcado	Puente Genil	Córdoba	SW	TRA-TM-SB-ST		Martínez Rodríguez 1990, Fig. 2; Arteaga Matute 2014, 116; Fig. 1

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H281	Cerro del Ahorcado	Puente Genil	Córdoba	SW	TRA-TE-SB		Martínez Rodríguez 1990, Fig. 2; Arteaga Matute 2014
H282	Cerro del Ahorcado	Puente Genil	Córdoba	SW	Large Asiego		Martínez Rodríguez 1990, Fig. 2; Arteaga Matute 2014
H283	Ifre	Mazarrón	Murcia	SE	TRA-TE-SA		Siret/Siret 1890, Fig. 18M; Montero Ruiz 1991, 363–365
H284	Ifre T2	Mazarrón	Murcia	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 18,2; Montero Ruiz 1991, 363–365; Lull et al. 2018, Tab. 3
H285	El Argar	Antas	Almería	SE	Small Asiego		Siret/Siret 1890, Fig. 26,1; Montero Ruiz 1991, 205–216
H286	El Argar	Antas	Almería	SE	TRA-TE-SA		Siret/Siret 1890, Fig. 26,2; Montero Ruiz 1991, 205–216
H287	El Argar	Antas	Almería	SE	TRA-TE-SA		Siret/Siret 1890, Fig. 26,3; Montero Ruiz 1991, 205–216
H288	El Argar	Antas	Almería	SE	TRA-TE-SA		Siret/Siret 1890, Fig. 26,5; Montero Ruiz 1991, 205–216
H289	El Argar	Antas	Almería	SE	TRA-TE-SA		Siret/Siret 1890, Fig. 26,6; Montero Ruiz 1991, 205–216
H290	El Argar T005	Antas	Almería	SE	TRI-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,5; Monteagudo 1977, No. 469; Fig. 25; B1; Fig. 144; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H291	El Argar T513	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 30,513; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H292	El Argar T654	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 31,654; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H293	El Argar T746	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 32,746; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H294	El Oficio	Antas	Almería	SE	TRA-TE-SA		Siret/Siret 1890, Fig. 62,3; Monteagudo 1977, No. 467; Fig. 25; Montero Ruiz 1991, 220–226
H295	El Argar T001	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,1; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H296	El Argar T208	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,208; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H297	El Argar T116	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,116; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H298	El Argar T048	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,48; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H299	El Argar T069	Antas	Almería	SE	TRI-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,69; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H300	El Argar T139	Antas	Almería	SE	TRI-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 29,139; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H301	El Argar T434	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 30,434; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H302	El Argar T538	Antas	Almería	SE	Small Asiego-var	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 30,538; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H303	El Argar T373	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 30,373; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H305	El Argar T554	Antas	Almería	SE	TRI-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 30,554; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H306	El Argar T580	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 30,580; Monteagudo 1977, No. 529; Fig. 27; G9; Fig. 145; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H307	El Argar T408	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 30,408; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H308	El Argar T497	Antas	Almería	SE	TRI-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 31,497; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H309	El Argar T585	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 31,585; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H310	El Argar T673	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 31,673; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H311	El Argar T572	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 31,572; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H312	El Argar T639	Antas	Almería	SE	Small Asiego-var	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 31,639; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H313	El Argar T693	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 31,693; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H314	El Argar T632	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 31,632; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H315	El Argar T189	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 32,189; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H316	El Argar T732	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 32,732; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H317	El Argar T768	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 32,768; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H318	El Argar T771	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 32,771; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3
H319	El Argar T703	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 32,703; Montero Ruiz 1991, 205–216; Lull et al. 2018, Tab. 3; Murillo-Barroso et al. 2024
H320	Indet	Indet	Indet	SE	TRA-TE-SA		Schubart/Ulreich 1991, No. 203
H321	El Oficio T072	Antas	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Siret/Siret 1890, Fig. 63,72; Monteagudo 1977, No. 461; Fig. 25; Montero Ruiz 1991, 220–226
H322	Cortijo Fuentidueñas	Écija	Sevilla	SW	TRA-TM-SB-ST		Photo/drawing by the authors; unpublished

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H323	Cueva del Moro de Alins del Monte	Litera	Huesca	EV	TRA-TE-SB	c. 1945–1470 BC	Rodanés Vicente et al. 2017,36; Fig. 1
H324	Indet	Jaén province	Jaén	SE	TRA-TE-SA		Harrison/Craddock 1981, Fig. 4,17; Monteagudo 1977, 563C; Fig. 156
H325	Indet	Granada province	Granada	SE	REC-TE-SB		Harrison/Craddock 1981, Fig. 4,19; Monteagudo; 1977, 589A; Fig. 156
H326	Indet	Jaén province	Jaén	SE	Small Asiego		Harrison/Craddock 1981, Fig. 4,20; Monteagudo 1977, 514A; Fig. 156
H327	Velefique	Velefique	Almería	SE	TRA-TE-SA		Harrison/Craddock 1981, Fig. 5,23; Monteagudo 1977, 93A; Fig. 4; Montero Ruiz 1991, 264
H328	Indet	Jaén province	Jaén	SE	TRA-TE-SA		Harrison/Craddock 1981, Fig. 5,24; Monteagudo 1977, 563D; Fig. 156
H329	Indet	Prov. Toledo	Toledo	SM	TRA-TM-SB-ST		Harrison/Craddock 1981, Fig. 5,24
H330	Villacarrillo	Villacarrillo	Jaén	SE	TRA-TM-SB-CC		Harrison/Craddock 1981, Fig. 6,27; Monteagudo 1977, 659A; Fig. 157
H331	Indet	Vélez Blanco	Almería	SE	TRA-TM-SB-ST		Photo by V. Schulmeister Guillén, MAN for CER.es, http://ceres.mcu.es, MCD, Spain; Consuegra Rodríguez 2007
H332	Codes	Codes	Guadalajara	SM	TRA-TM-SB-CC		Photo by L. Hernández Robles, MAN for CER.es, h ttp//ceres.mcu.es, MCD, Spain
H333	Codes	Codes	Guadalajara	SM	TRI-TE-SA		Photo by L. Hernández Robles, MAN for CER.es, http://ceres.mcu.es, MCD, Spain
H334	Codes	Codes	Guadalajara	SM	TRA-TE-SB		Photo by L. Hernández Robles, MAN for CER.es, http://ceres.mcu.es, MCD, Spain
H335	Codes	Codes	Guadalajara	SM	TRA-TM-SB-CC		Photo by L. Hernández Robles, MAN for CER.es, http://ceres.mcu.es, MCD, Spain
H336	Codes	Codes	Guadalajara	SM	TRA-TM-SB-CC		Photo by L. Hernández Robles, MAN for CER.es, http://ceres.mcu.es, MCD, Spain
H337	Indet	Región Bastetana	Murcia	SE	TRA-TE-SA		Photo by A. Rivas Rodríguez, MAN for CER.es, http://ceres.mcu.es, MCD, Spain
H338	Peal de Becerro	Peal de Becerro	Jaén	SE	TRA-TE-SB		Photo by V. Schulmeister Guillén, MAN for CER.es, http://ceres.mcu.es, MCD, Spain; Rovira Llorens et al. 1997, 232; Fig. 19
H339	Laiglesia	Laiglesia	Teruel	EV	TRA-TE-SB		Photo by V. Schulmeister Guillén, MAN for CER.es, http://ceres.mcu.es, MCD, Spain
H340	Villacarrillo	Villacarrillo	Jaén	SE	TRA-TM-SB-CC		Photo by V. Schulmeister Guillén, MAN for CER.es, http://ceres.mcu.es, MCD, Spain

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H341	Indet	Galicia province	Galicia	NW	Bujões/Barcelos		Photo by F. del Río Martínez, M. Arq. Prov Ourense for CER.es, http://ceres.mcu.es, MCD, Spain; Monteagudo 1977, No. 754; Fig. 44
H342	Cerro del Gallo	Fonelas	Granada	SE	TRA-TE-SA-var		Photo by I. de la Torre Castellano, M. Arq. Etnol. Granada for CER.es, http://ceres.mcu.es, MCD, Spain; Torre Peña/ Aguayo de Hoyos 1976
H343	Cortijo de Juan Cobos del Valle	Darro	Granada	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Photo by T. El Amrani Paaza, M. Arq. Etnol. Granada for CER.es, http://ceres.mcu.es, MCD, Spain; Lull 1983; Montero Ruiz 1991, 308
H344	Pantano de los Bermejales	Arenas del Rey	Granada	SE	Large Asiego		Photo by T. El Amrani Paaza, M. Arq. Etnol. Granada for CER.es, http://ceres.mcu.es, MCD, Spain; Arribas Palau/ Ferrer Palma 1997
H345	Serranía de Ronda	Serranía de Ronda	Málaga	SW	TRA-TE-SB		Photo by V. Rodríguez Escudero, M Arq Etnol Córdoba for CER.es, http://ceres.mcu.es, MCD, Spain
H346	El Zalabí	Esfiliana	Granada	SE	Small Asiego		Photo by T. El Amrani Paaza, M. Arq. Etnol. Granada for CER.es, http://ceres.mcu.es, MCD, Spain; García Sánchez/ Carrasco Rus 1979, Fig. 2,11
H347	El Zalabí	Esfiliana	Granada	SE	TRA-TE-SB-var		Photo by T. El Amrani Paaza, M. Arq. Etnol. Granada for CER.es, http://ceres.mcu.es, MCD, Spain; García Sánchez/ Carrasco Rus 1979; Montero Ruiz 1991, 310–311
H348	Monte Hacho	Salobreña	Granada	SE	TRA-TE-SA		Photo by T. El Amrani Paaza, M. Arq. Etnol. Granada for CER.es, http://ceres.mcu.es, MCD, Spain; Lull 1983
H349	Indet	Délica	Álava	N	TRA-TM-SB-ST		Drawing by Documentary Collection of the SAM project; Apellániz Castroviejo 1966
H350	Indet	Indet	Córdoba	SW	TRA-TE-SA		Drawing by Documentary Collection of the SAM project; unpublished
H351	Fonteta del Sarso?	Crevillente?	Alicante?	L?	TRA-TE-SA-var		Junghans et al. 1968, Fig. 2383
H352	Monteagudo	Monteagudo	Murcia	SE	TRA-TE-SA		Drawing by Documentary Collection of the SAM project; Montero Ruiz 1991, 354–355
H353	El Oficio T278	Cuevas de Almanzora	Almería	SE	TRI-TE-SA	c. 1800/1750–1550 BC	Photo by L. Hernández Robles, MAN for CER.es, http://ceres.mcu.es, MCD, Spain; Montero Ruiz 1991, 220–226; Lull et al. 2018, Tab. 3
H354	Peña Rubia	Lorca	Murcia	SE	TRA-TE-SA		Drawing by Documentary Collection of the SAM project; Montero Ruiz 1991, 371–372
H355	Indet	Castellar de Santisteban	Jaén	SE	REC-TE-SB		Drawing by Documentary Collection of the SAM project; unpublished
H356	Indet	Cartagena	Murcia	SE	Small Asiego		Rovira Llorens et al. 1997, 272; Fig. 24
H357	Indet	Osuna?	Sevilla	SW	Small Asiego-var		Drawing by Documentary Collection of the SAM project; unpublished

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H358	Calle S.Jeronimo	Granada	Granada	SE	REC-TE-SB		Drawing by Documentary Collection of the SAM project; Montero Ruiz 1991, 338
H359	Los Castillejos	Montefrío	Granada	SE	TRA-TM-SB-CC		García Sánchez/Carrasco Rus 1979, Fig. 1,7; Montero Ruiz 1991, 334
H360	El Zalabí	Esfiliana	Granada	SE	TRI-TE-SA		Drawing by Documentary Collection of the SAM project; García Sánchez/Carrasco Rus 1979; Montero Ruiz 1991, 310–311
H361	Indet	Región Bastetana	Murcia	SE	TRA-TE-SB		Drawing by Documentary Collection of the SAM project; unpublished
H362	Indet	Aguilar	Córdoba	SW	TRA-TM-SB-ST-var		Drawing by Documentary Collection of the SAM project; unpublished
H363	Llano de la Cuesta de Almiel 24	Gorafe	Granada	SE	TRA-TE-SB		Drawing by Documentary Collection of the SAM project; Montero Ruiz 1991, 285
H364	Indet	Castril	Granada	SE	REC-TM-SB		Drawing by Documentary Collection of the SAM project; Montero Ruiz 1991, 323
H366	Indet	Fuente Tójar	Córdoba	SW	TRA-TE-SA		Drawing by Documentary Collection of the SAM project; unpublished
H367	Indet	Fuente Tójar	Córdoba	SW	TRI-TE-EB		Drawing by Documentary Collection of the SAM project; unpublished
H368	El Oficio T238	Cuevas de Almanzora	Almería	SE	TRA-TE-SA	c. 1800/1750–1550 BC	Drawing by Documentary Collection of the SAM project; Montero Ruiz 1991, 220–226; Lull et al. 2018, Tab. 3
H369	El Oficio	Cuevas de Almanzora	Almería	SE	TRI-TE-SA		Drawing by Documentary Collection of the SAM project; Montero Ruiz 1991, 220–226
H370	Cova de Sa Talaia	Sta Margalida	Mallorca	BI	Bujões/Barcelos	LBA (Naviforme II)	Delibes de Castro et al. 1988, 15; Fig. 2; Salvà Simonet 2013, 542; Annex 1
H371	Indet	Vélez Blanco	Almería	SE	TRA-TE-SA		Drawing by Documentary Collection of the SAM project; Montero Ruiz 1991, 257
H372	Indet	Vélez Blanco	Almería	SE	REC-TE-SB		Drawing by Documentary Collection of the SAM project; Montero Ruiz 1991, 257
H373	Cerro de Gabal	Vélez Blanco	Almería	SE	REC-TE-SB		Drawing by Documentary Collection of the SAM project; Montero Ruiz 1991, 236
H374	Cova de Sa Talaia	Sta Margalida	Mallorca	BI	Bujões/Barcelos	LBA (Naviforme II)	Delibes de Castro et al. 1988, 15; Fig. 2; Salvà Simonet 2013, 542; Annex 1
H378	Cova M del Cingle Blanc	Arbolí	Tarragona	NE	REC-TE-SB-var		Martín Cólliga et al. 1999, 137; Fig. 5,6; Soriano 2013, 91–96; Balaguer et al. 2011; Montero Ruiz 2017
H379	Castillo de Alburquerque	Alburquerque	Badajoz	SW	Yunclillos-var		Monteagudo 1977, 356; Fig. 19; Enríquez Navascués/Palomo Lechón 2011; Gómez Ramos et al. 1999
H380	Estepa	Estepa	Sevilla	SW	Yunclillos		Ruiz-Taboada et al. 2019, Fig. 8

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
H381	Estepa	Estepa	Sevilla	SW	Yunclillos		Ruiz-Taboada et al. 2019, Fig. 8
H382	Estepa	Estepa	Sevilla	SW	Yunclillos		Ruiz-Taboada et al. 2019, Fig. 8
H383	Estepa	Estepa	Sevilla	SW	Yunclillos		Ruiz-Taboada et al. 2019, Fig. 8
H384	Estepa	Estepa	Sevilla	SW	Large Asiego-var		Ruiz-Taboada et al. 2019, Fig. 8
H385	Estepa	Estepa	Sevilla	SW	Yunclillos		Ruiz-Taboada et al. 2019, Fig. 8
H386	Arbocer	Font de la Figuera	Valencia	L	REC-TE-SB	c. 1438–1306 BC (Beta-32794 = 3120 ± 30 BP/ Beta-260427 = 3120 ± 40 BP)	García Borja et al. 2005, Fig. 3,8; Pedro Michó/García Borja 2015
H387	Cova de Muricecs	Llimiana	Lleida	NE	Small Asiego		Montero–Ruíz et al. 2015, Fig. 5,1849; Gallart 2006; Soriano 2013, 91–96
HR001	Oviedo	Oviedo	Asturias	N	REC-TM-SB		Monteagudo 1977, No. 786; Fig. 47; Blas Cortina 1999
HR002	Oix	Oix	Girona	NE	TRI-TE-EB		Monteagudo 1977, No. 795; Fig. 48; Soriano 2013, 96–101
HR003	Puigcerdà	Puigcerdà	Girona	NE	TRI-TE-EB		Photo/drawing by the authors; Soriano 2013, 96–101
HR004	Las Paules	Barbastro	Huesca	EV	TRA-TE-SA		Barril 1982, Fig. 1; Rodríguez de la Esperanza 2005; Soriano 2013
HR005	Sierra de Carrodilla	Ólvena	Huesca	EV	TRA-TE-SB		Rovira Llorens et al. 1997, 230; Fig. 18; Rodríguez de la Esperanza 2005; Soriano 2013
HR006	Bardena de Cáseda	Bardena de Cáseda	Navarra	EV	REC-TE-SA		Ona González/Pérez Casas 1985, 36; Fig. 1
HR007	Bardena de Cáseda	Bardena de Cáseda	Navarra	EV	Small Asiego-var		Ona González/Pérez Casas 1985, 36; Fig. 2
HR008	Plana d'Ancosa	Querol	Tarragona	NE	TRI-TE-EB		Martín Cólliga et al. 1999, 137; Fig. 5,8; Soriano 2013, 96–101
HR009	Arcos de Valdevez	Arcos de Valdevez	Minho	NW	TRA-TM-SB-ST		Monteagudo 1977, No. 154; Fig. 8; Comendador Rey 1997, 188
HR010	Penafiel	Porto	Douro Litoral	NW	Bujões/Barcelos		Monteagudo 1977, No. 781; Fig. 47; Bettencourt/ Comendador Rey 2004
HR011	Retuerta	Retuerta	Burgos	NM	TRA-TE-SA		Monteagudo 1977, No. 607A; Fig. 33; Herrán Martínez 2008, 44; Fig. 22,4
HR012	Cova B d'Olopte	Isòvol	Girona	NE	TRA-TE-SA		Monteagudo 1977, No. 796A; Fig. 48; Soriano 2013, 96–101
HR013	Mas de la Miquelona	Alcarràs	Lleida	NE	REC-TE-SB		González 1985, 41; Fig. 1; Soriano 2013, 96–101
HR014	Cova de Font Major	Espluga de Francolí	Tarragona	NE	REC-TM-SB		Monteagudo 1977, No. 811; Fig. 49; Soriano 2013, 96–101
HR015	Indet	Fraga?	Huesca / Zaragoza	EV	REC-TE-SB		Aguilera Aragón 2019, 357; Fig. 5
HR016	Indet	Palencia province	Palencia	NM	REC-TM-SB-var		Photo by V. Schulmeister Guillén, MAN for CER.es, http://ceres.mcu.es, MCD, Spain

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
M001	Ses Tavernes	Ciutadella	Menorca	BI	TRA-TE-SB		Delibes de Castro et al. 1988, 151; 81; Fig. 39; Nicolás/Sánchez 1985; Fraile Vicente 2007, 487
M002	Artana	Artana	Castellón	L	TRI-TE-EB		Simón García 1998, 176; Fig. 103; Fraile Vicente 2007, 190
M003	Mola Alta de Serelles 1 (A)	Alcoi	Alicante	L	Small Asiego-var	c. 2000–1550 BC	Simón García 1998, 112; Fig. 68,3; Monteagudo 1977, No. 523A; Fig. 156; Fraile Vicente 2007, 238
M004	Mola Alta de Serelles 1 (B)	Alcoi	Alicante	L	TRI-TE-SA	c. 2000–1550 BC	Simón García 1998, 112; Fig. 68,3; Monteagudo 1977, No. 523A; Fig. 156; Fraile Vicente 2007, 238
M005	Mola Alta de Serelles 2	Alcoi	Alicante	L	TRI-TE-EB	c. 2000–1550 BC	Simón García 1998, 112; Fig. 67,2; Monteagudo 1977, No. 523Ba; Fig. 156; Fraile Vicente 2007, 237
M006	Mola Alta de Serelles 3	Alcoi	Alicante	L	TRI-TE-EB	c. 2000–1550 BC	Simón García 1998, 112; Fig. 69,1; Monteagudo 1977, No. 523Ca; Fig. 156; Fraile Vicente 2007, 242; Peres 2021, Fig. 3,80
M007	Mola Alta de Serelles 4	Alcoi	Alicante	L	TRI-TE-SA	c. 2000–1550 BC	Simón García 1998, 112; Fig. 66,1; Fraile Vicente 2007, 239
M008	Orpesa la Vella	Orpesa	Castellón	L	TRI-TE-SA	c. 2009–1691 BC (I-15902 = 3510 ± 100 BP)	Gusi/Olària 2014, Fig. 107; Simón García 1998, 169; Fraile Vicente 2007, 253
M009	Cerro Lutero (A)	Villalba de la Sierra	Cuenca	SM	TRA-TM-SB-CC		Díaz-Andreu García/Montero Ruiz 1998, Fig. 27; Fraile Vicente 2007, 285
M010	Cerro Lutero (B)	Villalba de la Sierra	Cuenca	SM	REC-TM-SB		Díaz-Andreu García/Montero Ruiz 1998, Fig. 27; Fraile Vicente 2007, 285
M011	El Molino de Garrejo (A)	Garray	Soria	NM	TRI-TE-EB		Morales Hernández 2018, Fig. 4
M012	El Molino de Garrejo (B)	Garray	Soria	NM	TRI-TE-EB		Morales Hernández 2018, Fig. 4
M013	Loma del Lomo	Cogolludo	Guadalajara	SM	TRA-TE-SA	c. 2189–1519 BC (I-15838 = 3620 ± 110 BP; I-15837 = 3370 ± 100 BP)	Valiente Malla 2001, 19–22; Fig. 11; 262–263
M014	Alto de la Loma	Quintanilla de Onsoña	Palencia	NM	REC-TE-SA		Cortés/Ríos 1979, Fig. 4; Delibes de Castro et al. 1999, 82; Fraile Vicente 2007, 336; Herrán Martínez 2008, 107
M015	El Otero_MS (A)	Caracenilla	Cuenca	SM	REC-TE-SB-var		Díaz-Andreu García/Montero Ruiz 1998, Fig. 9; Fraile Vicente 2007, 293
M016	El Otero_MS (B)	Caracenilla	Cuenca	SM	TRA-TE-SB		Díaz-Andreu García/Montero Ruiz 1998, Fig. 9; Fraile Vicente 2007, 293
M017	Bages o Olius	Bages o Olius	Barcelona	NE	TRA-TE-SA		Monteagudo 1977, No. 777; Fig. 46; Soriano 2013, 69–70; Fraile Vicente 2007, 401
M018	Forat de la Tuta 1	Riner	Lleida	NE	TRA-TE-SB	c. 1670–1534 BC (LTL-4236A = 3335 ± 45 BP)	Monteagudo 1977, No. 566A; Fig. 29–30; Soriano 2013, 69–70; Fraile Vicente 2007, 370
M019	Forat de la Tuta 2	Riner	Lleida	NE	TRA-TE-SA	c. 1670–1534 BC (LTL-4236A = 3335 ± 45 BP)	Monteagudo 1977, No. 566B; Fig. 30; Soriano 2013, 69–70; Fraile Vicente 2007, 369

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
M020	La Sort del Sales (A)	Vallclara	Tarragona	NE	TRA-TE-SA		Photo/drawing by the authors; Maya 2002; Soriano 2013, 69–70
M021	La Sort del Sales (B)	Vallclara	Tarragona	NE	TRA-TE-SA		Photo/drawing by the authors; Maya 2002; Soriano 2013, 69–70
M022	Minferri 1	Juneda	Lleida	NE	TRA-TE-SA		Photo/drawing by the authors; Equip Minferri 1997; Soriano 2013, 69–70; Fraile Vicente 2007, 398
M023	Cháo do Bordel	Santiago de Samarugo	Lugo	NW	Small Asiego		Monteagudo 1977, No. 67; Fig. 3; Comendador 1997, 68; 1999; Fraile Vicente 2007, 464
M024	Corga da Mela	Herosa	Ourense	NW	Bujões/Barcelos		Monteagudo 1977, No. 735A–B; Fig. 150; Comendador Rey 1999, 350; Fraile Vicente 2007, 463
M025	Monte do Castro (A)	Dena	Pontevedra	NW	REC-TM-SB		Comendador Rey 1996, Fig. 1; Comendador Rey 1997, 148; Fraile Vicente 2007, 458
M026	Monte do Castro (B)	Dena	Pontevedra	NW	_		Comendador 1996, Fig. 2; Comendador 1997, 148; Fraile Vicente 2007, 458
M027	Cuesta del Negro (A)	Purullena	Granada	SE	TRA-TE-SA	Argar	Molina González/Pareja López 1975, 36–37; Fig. 50; Montero Ruiz 1991, 319; Fraile Vicente 2007, 46
M028	Cuesta del Negro (B)	Purullena	Granada	SE	REC-TE-SB	Argar	Molina González/Pareja López 1975, 36–37; Fig. 51; Montero Ruiz 1991, 319; Fraile Vicente 2007, 46
M029	El Argar 1	Antas	Almería	SE	TRI-TE-SA		Siret/Siret 1890, Fig. 27,4; Monteagudo 1977, No. 541; Fig. 28; Montero Ruiz 1991, 207; Fraile Vicente 2007, 49
M030	El Argar 2	Antas	Almería	SE	TRI-TE-SA		Siret/Siret 1890, Fig. 27,1; Monteagudo 1977, No. 542; Fig. 28; Montero Ruiz 1991, 207; Fraile Vicente 2007, 48
M031	Peñalosa 3	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 218,14; Fig. 9,3.8; 13,75.6; Fraile Vicente 2007, 61
M032	La Almoloya	Pliego-Mula	Murcia	SE	TRA-TE-SA		Lull et al. 2015, 108; Fig. 1
M033	La Bastida 1	Totana	Murcia	SE	TRA-TE-SA		Ache Delgado 2019, 202–203; Fig. 5,65; Fig. 26; Lull et al. 2015a, 112
M034	Peñalosa 1	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 147; 193–195; 218,4; Fig. 7,4; Fig. 9,3.6; Fig. 13,24; Fig. 9,10.1; Fraile Vicente 2007, 61
M035	Peñalosa 11	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 218,30; Fig.13,140.13; Fraile Vicente 2007, 61
M036	Peñalosa 2 (A)	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 147; 193–195; 218,40; Fig. 13,176.15; Fig. 9,10.2; Fraile Vicente 2007, 61
M037	Peñalosa 2 (B)	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 147; 193–195; 218,40; Fig. 13,17.15; Fig. 9,10.2; Fraile Vicente 2007, 61
M038	Peñalosa 7	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 218,15; Fig. 13,86.5; Fraile Vicente 2007, 61

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
M039	Yecla 1	Yecla	Murcia	SE	TRA-TE-SA		Simón García et al. 1999, 40; Fig. 1,10; Rauret 1976; Fraile Vicente 2007, 509
M040	Yecla 2	Yecla	Murcia	SE	TRA-TE-SA		Simón García et al. 1999, 41; Fig. 1,11; Rauret 1976; Fraile Vicente 2007, 509
M041	Murviedro	Lorca	Murcia	SE	TRA-TE-SA-var	c. 1400–1200 BC (KIA-29172 = 3090 ± 30 BP; KIA-29173 = 3005 ± 30 BP)	Delgado Raack 2013, 17; Fig. 4; Pujante et al. 2002, 28
M042	Gatas	Turre	Almería	SE	TRA-TE-SA	Post-Argar	Risch 1995, Fig. 50,54; Chapman et al. 1987, 300; Fig. 2; Montero Ruiz 1991, 233; Fraile Vicente 2007, 57
M043	Las Minitas	Almendralejo	Badajoz	SW	TRA-TE-SA		Photo by M. Arq. Prov. Badajoz; Pavón Soldevila et al. 1993, Fig. 6; Hunt Ortiz 2003, 331–333; Fig. 139B
M044	Santaella	Santaella	Córdoba	SW	REC-TE-SB		Photo/drawing by the authors; unpublished; Municipal Historical Museum of Santaella. No. 153
M045	Huici	Larraún	Navarra	EV	TRI-TE-SA		Merino 1965, Fig. 1; Fraile Vicente 2007, 458
M046	La Hoya Quemada	Mora de Rubielos	Teruel	EV	TRA-TE-SB	c. 1950–1655 BC (UGRA-211 = 3260 ± 100 BP; UGRA-212 = 3450 ± 90 BP; UGRA-213 = 3420 ± 100 BP)	Burillo/Picazo 1986, Fig. 4; Fraile Vicente 2007, 106; Rodríguez de la Esperanza 2005, 64; Fig. 4,10
M047	Los Chaparros	Albalate del Arzobispo	Teruel	EV	TRA-TE-SB		Photo by B. Ezquerra Lebrón, Museum of Teruel; Royo Lasarte 1999
M048	Pantano de Santa Ana	Castillonroy	Huesca	EV	TRA-TE-SA		Maya 1991, Fig. 4,2; Fraile Vicente 2007, 98; Rodríguez de la Esperanza 2005, 64
M049	Arenero de la Fuente de la Bruja	Villaverde	Madrid	SM	TRI-TE-?		Sánchez Meseguer et al. 1983, 46; Fig. 1; Fraile Vicente 2007, 186
M050	Minferri 2	Juneda	Lleida	NE	TRI-TE-?		Photo/drawing by the authors; Equip Minferri 1997; Soriano 2013, 69–70; Fraile Vicente 2007, 397
M051	Minferri 3	Juneda	Lleida	NE	TRA-TE-SA	c. 1919–1746 BC (UBAR-549 = 3510 ± 60 BP)	Photo/drawing by the authors; Equip Minferri 1997; Soriano 2013, 69–70; Fraile Vicente 2007, 397
M052	El Oficio	Cuevas de Almanzora	Almería	SE	TRA-TE-?		Siret/Siret 1890, Fig. 62; 56; Montero Ruiz 1991, 220–226; Fraile Vicente 2007, 54
M053	El Tabayá	Aspe	Alicante	L	_		Simón García 1998, 71; Fig. 41,1; Fraile Vicente 2007, 225
M054	La Bastida 2	Totana	Murcia	SE	TRA-TE-?		Monteagudo 1977, No. 506; Fig. 26; Montero Ruiz 1991, 367; Fraile Vicente 2007, 498
M055	Los Tintes	Lorca	Murcia	SE	TRA-TE-?		Delgado Raack 2008, 381–383; Fig. 4,1.60D; Fig. 18
M056	Peñalosa 15	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 218,40; Fig. 13,178.1; Fraile Vicente 2007, 61
M057	Peñalosa 5	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 218,14; Fig. 9,3.8; 13,76.1; Fraile Vicente 2007, 61

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
M058	Barranco de la Terolana	Hinojosa de Jarque	Teruel	EV	TRA-TE-SA	LBA	Simón Domingo et al. 1988, 77; Fig. 12; Rodríguez de la Esperanza 2005, 64; Fraile Vicente 2007, 92
M059	Minferri 4	Juneda	Lleida	NE	_		Photo/drawing by the authors; Soriano 2013, 69–70
M060	Cabezo Redondo 1	Villena	Alicante	L	TRA-TE-?	c. 1747–1333 BC	Simón García 1998, 91; Fig. 57,2; Soler García 1987; Fraile Vicente 2007, 196
M061	Cabezo Redondo 2	Villena	Alicante	L	REC-TE-SB	c. 1747–1333 BC	Hernández Pérez et al. 2016, 95; Fig. 1
M062	Cabezo Redondo 4	Villena	Alicante	L	_	c. 1747–1333 BC	Photo by G. García Atiénzar, University of Alicante; unpublished
M063	Cabezo Redondo 5	Villena	Alicante	L	TRA-TE-?	c. 1747–1333 BC	Photo by G. García Atiénzar, University of Alicante; unpublished
M064	Monte Aguilar	Bardenas Reales	Navarra	EV	REC-TM-SB?		Drawing by J. Sesma Sesma, Directorate-General for Culture, Government of Navarre; Sesma Sesma/García García 1994
M065	Cabezo Redondo 3	Villena	Alicante	L	_	c. 2007–1774 BC (H-2277 = 3550 ± 55 BP)	Simón García 1998, 91; Fig. 57,4; Soler García 1987, Fig. 38,4; Fraile Vicente 2007, 197
M066	Cabezo Redondo 6	Villena	Alicante	L	_	c. 1747–1333 BC	Photo by G. García Atiénzar, University of Alicante; unpublished
M067	Can Roqueta II	Sabadell	Barcelona	NE	_	c. 1738–1549 BC (UBAR-800 = 3360 ± 70 BP)	Photo/drawing by the authors; Soriano 2013, 69–70
M068	Fraga dos Corvos	Macedo de Cavaleiros, Bragança	Trás-Os-Montes	NW	Bujões/Barcelos	c. 1700 BC	Senna-Martinez/Cardoso 2010, Fig. 8
M069	Peñalosa 12 (A)	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 218,37; Fig. 13,168.11; Fraile Vicente 2007, 61
M070	Peñalosa 13	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 218,37; Fig. 13,168.14; Fraile Vicente 2007, 61
M071	Peñalosa 14	Baños de la Encina	Jaén	SE	Axe-shaped ingot		No photo/drawing; Contreras Cortés 2000, 218,40; Fraile Vicente 2007, 61
M072	Peñalosa 12 (B)	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 218,37; Fig. 13,168.11; Fraile Vicente 2007, 61
M073	Peñalosa 4	Baños de la Encina	Jaén	SE	Axe-shaped ingot		No photo/drawing; Contreras Cortés 2000, 218,6; Fraile Vicente 2007, 61
M074	Peñalosa 6	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 218,15; Fig. 13,86,1; Fraile Vicente 2007, 61
M075	Peñalosa 8	Baños de la Encina	Jaén	SE	Axe-shaped ingot		No photo/drawing; Contreras Cortés 2000, 218,20; Fraile Vicente 2007, 61
M076	Peñalosa 9	Baños de la Encina	Jaén	SE	Axe-shaped ingot		No photo/drawing; Contreras Cortés 2000, 218,23; Fraile Vicente 2007, 61
M077	Minferri 5	Juneda	Lleida	NE	_		Photo/drawing by the authors; Soriano 2013, 69–70
M078	Minferri 6	Juneda	Lleida	NE	_		Photo/drawing by the authors; Soriano 2013, 69–70

No.	Site	Locality	Province	Region	Taxon	Dating	Reference
M079	S'Hospitalet 1	Manacor	Mallorca	BI	_	LBA (Naviforme II)	Roselló Bordoy 1987; Fig. 1–3; Salvà Simonet 2013; 532
M080	S'Hospitalet 2	Manacor	Mallorca	BI	_	LBA (Naviforme II)	Roselló Bordoy 1987; Fig. 1–3; Salvà Simonet 2013; 532
M081	Cala Blanca	Ciutadella	Menorca	BI	TRA-TE-SA	c. 1421–1300 BC (IRPA-1124 = 3100 ± 40 BP)	Sureda 2022; Fig. 4; Salvà Simonet 2013; 532; Salvà Simonet 2018; 456; Fig. 5,18
M082	Monte das Carballas	Guillade, Pontearas	Pontevedra	NW	Bujões/Barcelos		Suárez Otero et al. 1997; Fig. 3,1–3; Comendador Rey 1999; 350
M083	La Serna	Arganda del Rey	Madrid	SM	TRA-TM-SB-CC	c. 1599–1460 BC (17B/0159 = 3260 ± 30 BP)	Photo by L. Galindo San José; Arqueoestudio; Galindo San José et al. 2018
M084	Cerro de las Víboras de Bajil	Moratalla	Murcia	SE	_		No photo/drawing; Eiroa García 2002
M085	Castell d'Almassora	Almassora	Castellón	L	TRA-TE-SA/B		Photo/drawing by the authors; Esteve Gálvez 1969; Fraile Vicente 2007, 215; Castelló Museum of Fine Arts; No. indet
M086	Castellet de la Plana	Castelló de la Plana	Castellón	L	TRA-TE-SA-var		Photo/drawing by the authors; Oliver Foix et al. 2005; Castelló Museum of Fine Arts, No. 2072
M087	Castell de Bairén	Gandía	Valencia	L	_		Simón García 1998, 141; Fig. 79,1
M088	Pico Nabo o Puntal del Nabo	Segorbe	Castellón	L	_		No photo/drawing; Simón García 1998, 181
M089	O Grove	Cambados	Pontevedra	NW	_		Carro Otero et al. 1983, Fig. 1; Fraile 2007, 459
M090	El Bordellet	Vilafranca del Penedès	Barcelona	NE	TRA-TE-SB	c. 1850–1700 BC	Segura/Medina 2015, vol. VII; Fig. 22
M091	A Sola	Braga	Minho	NW	Bujões/Barcelos	c. 1673-1527 BC	No photo/drawing; Bettencourt 2000; Bettencourt/Comendador Rey 2004
M092	Cimalha	Felgueiras	Douro Litoral	NW	Bujões/Barcelos		Vieira 2014, 59; Fig. 5
M093	Carricastro	Tordesillas	Valladolid	NM	TRA-TE-?	Cogotas 1	Delibes de Castro et al. 2010, Fig. 1
M094	Piedrahita	Mucientes	Valladolid	NM	REC-TE-?		Delibes de Castro et al. 2010, Fig. 2
M095	Collado de la Abeja	Muel / Alfamén	Zaragoza	EV	_	c. 1650–1500 BC	Photo/drawing by J. V. Picazo, University of Zaragoza; Pérez-Lambán et al. 2018
M096	Peñalosa 10	Baños de la Encina	Jaén	SE	Axe-shaped ingot		Contreras Cortés 2000, 218,24; Fig. 13,119,13; Fraile Vicente 2007, 61

Annex 1 Provenance of 367 axes and the 96 matrices included in this study. Apart from published information, many axes and moulds were measured and described according to the original pieces. Dating of axes and moulds is based on absolute and relative indicators. BI Balearic Islands; L Levante; EV Ebro Valley; N North; NE North-East; NM North Meseta; NW North-West; SE South-East; SM Southern Meseta; SW South-West.

Annex 1 *Fundorte der in dieser Untersuchung enthaltenen 367 Beile und 96 Matrizen. Nicht nur die publizierten Daten der Beile und Gussformen wurden genutzt, viele wurden auch anhand der Originalstücke vermessen und beschrieben. Die Datierung basiert auf absoluten und relativen Indikatoren. BI Balearen; L Levante; EV Ebro-Tal; N Norden; NE Nordosten; NM nördliche Meseta; NW Nordwesten; SE Südosten; SM südliche Meseta; SW Südwesten.*

Beyond utility: Metal axes in the funerary contexts of El Argar in the south-eastern Iberian Peninsula during the Bronze Age (2200–1550 cal BC)

Bárbara Bonora Soriano

Zusammenfassung

Mehr als nur praktisch: Metallbeile im Bestattungskontext der El-Argar-Kultur im Südosten der Iberischen Halbinsel während der Bronzezeit (2200–1550 cal BC)

Die Bestattungen der El-Argar-Kultur stellen eine besonders geeignete Quelle dar, um die soziopolitische Organisation der frühbronzezeitlichen Gesellschaft (2200–1550 cal BC) in Südostspanien zu verstehen. Dieser Beitrag zielt darauf ab, den Zusammenhang zwischen dem gesellschaftlichen Wert der Grabbeigaben, allen voran der Beile, und den ideologisch-politischen Überlegungen der mit ihnen rituell verbundenen Individuen zu erforschen. Anhand einer Gruppe von Bestattungen am Fundort El Argar, Antas, Almería (Spanien) und dem Vergleich mit solchen von anderen Fundorten der El-Argar-Kultur, auch unter Berücksichtigung neuer Arbeitsmethoden, wie der mikroräumlichen Untersuchung der Gräber, werden wir die Daten der mit Beilen ausgestatteten Gräber, aber auch ihre Bedeutung im gesellschaftlichen Kontext, neu interpretieren. Anschließend soll aufgezeigt werden, wie Artefakte mit einer ursprünglich eher praktischen Funktion als Waffe oder Werkzeug dann in Begräbnisriten zu wichtigen Objekten der Kommunikation wurden. Zum Schluss wird die bedeutende Rolle der Beile erörtert, wenn es um die symbolische Unterscheidung männlicher Individuen geht, die eine bestimmte gesellschaftliche Stellung repräsentieren wollten, und wie diese durch eine wiederkehrende Grabgestaltung verdeutlicht wurde.

Schlagwörter Bestattungssitten, El Argar, Frühbronzezeit, Beilnutzung, räumliche Verteilung

Summary

The funerary contexts of the El Argar archaeological group constitute an exceptional source for understanding the socio-political organisation of the Early Bronze Age society (2200–1550 cal BC) in south-eastern Spain. The aim of this paper is to explore the link between the social value of the objects included in the tombs, with a special focus on the axes, and the ideological-political consideration of the individuals ritually associated with them. Through a group of tombs from the site of El Argar, Antas, Almería (Spain), and their comparison with those from other sites of the same archaeological group, while considering new lines of work such as the microspatial study of the tombs, we will update the interpretation of the data on Argaric tombs with axes and their importance in their social context. Next, we will show how axes with an originally practical function, either as a weapon or a tool, became important objects of communication in funerary scenarios. Finally, the important role that axes played in the symbolic distinction of male individuals, who sought to represent a concrete social figure and to reinforce it through a recurrent funerary composition, will be discussed.

Keywords funerary practices, El Argar, Early Bronze Age, axeman, spatial composition

Exploring funerary practices in the Argaric society: An overview of tombs with axes

Argaric axes had a »social life« that went through different phases: production, distribution, use, and consumption. This paper specifically focuses on a particular consumption scenario: the funerary context. Argaric tombs constituted repositories of social work in which objects were »written off« by being deposited as grave goods next to the deceased bodies of some individuals rather than being further used by those still alive.

In the Argaric world, a wide repertory of these objects existed, which included pottery as containers for offerings (eight pottery types are distinguished); ornaments such as diadems, earrings, rings, bracelets, or necklace beads; and tools or weapons, including halberds, swords, awls, sharpeners, and daggers/knives, and, most importantly for this work – axes. The access to these items in the funerary spaces was unequal and was influenced by age and sex. Additionally, it underwent significant changes throughout the lifespan of El Argar (Castro et al. 1994). These material differences provided a propitious setting for the study of the social organisation (e.g., Alarcón/Mora 2014; Cámara/

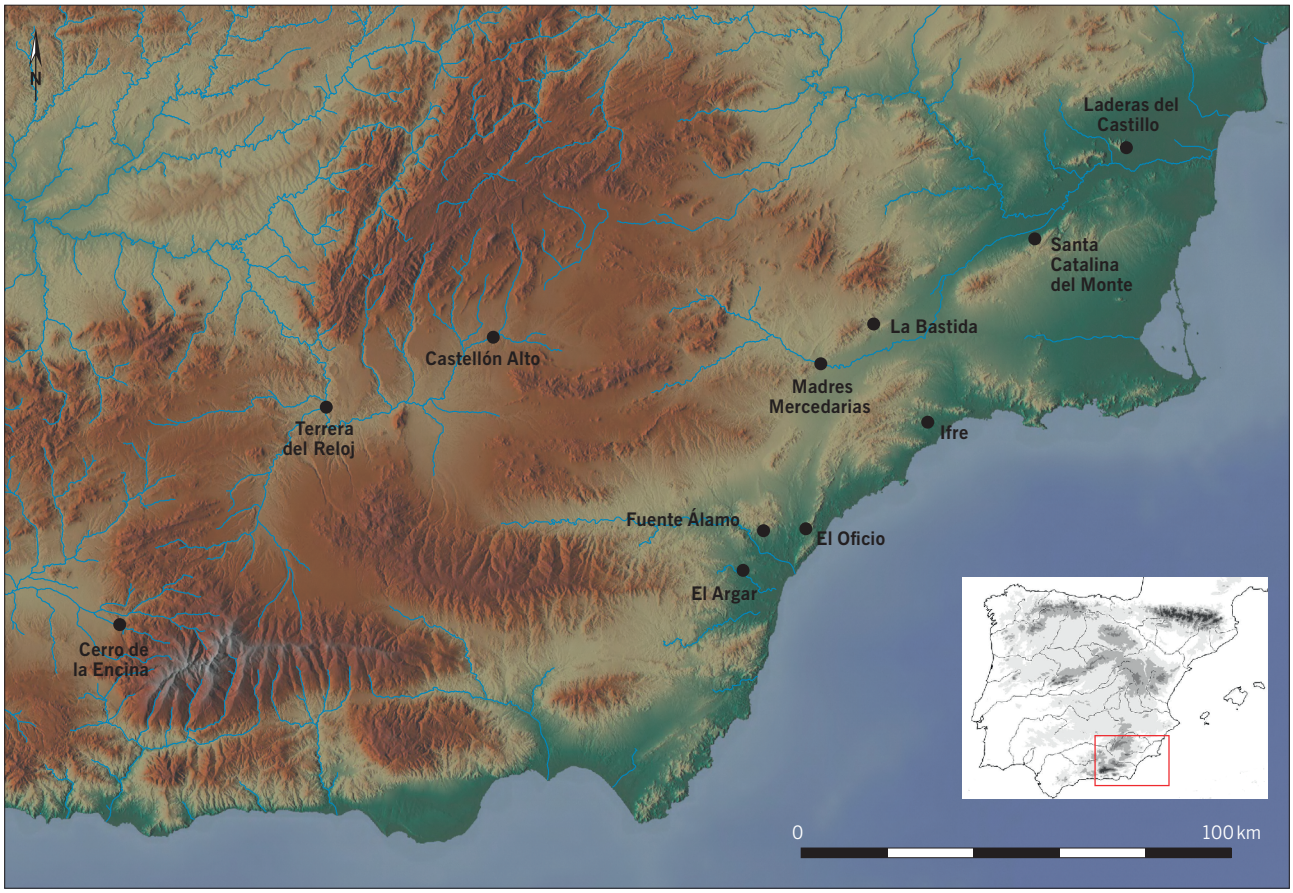

Fig. 1 Topographical map showing the location on the Iberian Peninsula of the Argaric sites featured in this study.

Abb. 1 *Karte der in dieser Untersuchung behandelten Fundorte der El-Argar-Kultur auf der Iberischen Halbinsel.*

Molina 2010; Cámara/Molina 2011) and the formulation of proposals for social categorisation.

In the case of axes, their association with male individuals was quickly recognised (Siret/Siret 1890) and, over time, the results of several anthropological studies have confirmed the exclusive relation between axes and males (Lull et al. 2018). Age was also a relevant factor, as axes were mainly found in connection with adult individuals. It is true, however, that there are a few examples of infant individuals buried with axes, indicating that this item could have been acquired at any age[1].

The inclusion of axes among grave goods did not extend throughout the entire Argaric diachrony (2200–1550 cal BC) but was limited to phase III of El Argar (c. 1800/1750–1550 cal BC; Castro et al. 1994). This has been linked with a possible replacement of axes with older halberds, typical of the Argaric phase II (c. 2000–1800 cal BC). However, the substitution of one weapon for another did not imply that their social consideration remained the same (Lull et al. 2018, 241). The proposal by V. Lull and J. Estévez (Lull/Estévez 1986), which established statistical distinctions between the Argaric grave goods assemblages and associated them with three distinct social categories, placed axes – together with daggers/knives, awls, and ceramic types 4 and 8 – in a hierarchically lower category than the halberds. The former was interpreted as belonging to full members of the community, whereas the latter were closely linked with the ruling class.

Despite numerous achievements in archaeological research, the predominant focus has been on assessing the value and wealth associated with axes found in tombs. The purpose of this paper is to explore the social value of tombs containing axes through a study focused on the ritual dimension, using the archaeological objects present in these tombs as a basis. A micro-spatial analysis of the arrangement of these objects is proposed to identify patterns and repetitions in order to better understand funerary practices and reveal symbolic aspects.

Material and methods

This work is based on an exhaustive review of the literature on Argaric funerary finds, specifically those that include axes as part of the grave goods. Various sources have been

1 This, in conjunction with the exclusive association of axes with males, made it possible to infer that these infant individuals were boys.

consulted, ranging from field diaries to specialised monographs, with the aim of compiling detailed information on each tomb as a whole. In total, 81 tombs have been analysed: 59 from El Argar (Antas, Almería), seven from El Oficio (Cuevas de Almanzora, Almería), six from La Bastida (Totana, Murcia), two from Laderas del Castillo (Callosa de Segura, Alicante), and one each from the sites of Fuente Álamo (Cuevas de Almanzora, Almería), Castellón Alto (Galera, Granada), Madres Mercedarias (Lorca, Murcia), Santa Catalina del Monte (Murcia), Cerro de la Encina (Monachil, Granada), Terrera del Reloj (Dehesas de Guadix, Granada), and Ifre (Mazarrón, Murcia; Fig. 1).

The information on the tombs has been synthesised in Tab. 1–3, which include basic identification data, location, type of container, number of individuals, sex, and age, as well as details on the grave goods. For the individual tombs from El Argar, spatial information on the position of the objects has also been added.

It should be noted that the record of this collection of tombs presents disparities stemming from diverse archaeological traditions and the methodologies followed by different authors. Addressing this challenge required a meticulous design of an analysis strategy to overcome the limitations inherent in the variability of the available archaeological record. The ultimate goal is to extract a maximum of detailed information related to the placement of objects in the tombs, enabling a robust comparison between them. To achieve this, descriptive and, above all, graphic information has been considered.

The material used to conduct the spatial analysis of the tombs has primarily focused on the site of El Argar. The graphic information is derived from the excavation diaries maintained by the Flores family under the direction of the Siret brothers[2]. These diaries provide a description of funerary finds and include sketches that reflect the placement of objects inside the tombs. A method was developed for this purpose, involving the division of each tomb into nine spatial sectors (Fig. 2). This method assigns a quadrant number to each object found in the tomb, enabling statistical testing of the significance of the observed distributions.

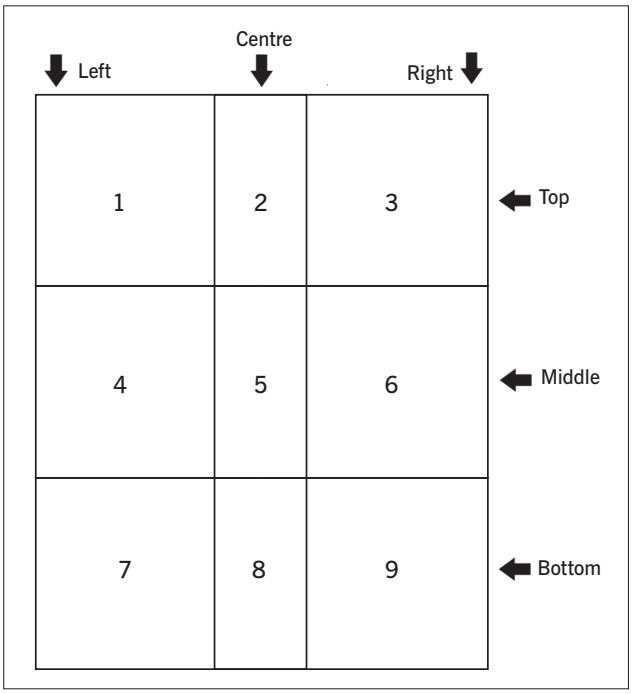

Fig. 2 9-quadrant grid for the schematic zoning of the funerary space. This scheme has been used to record the position of the different grave goods within each burial. The numbers indicate the code of a specific zone.

Abb. 2 *Raster mit neun Feldern zur schematischen Einteilung der Bestattungsstelle. Dieses Schema wurde dazu verwendet, die Position verschiedener Beigaben innerhalb eines Grabes zu erfassen. Die Felder werden wie dargestellt durchnummeriert.*

Comparative analysis of grave goods placement

The analysis has been structured into different sections based on the quantity and quality of the data, using an integrative approach aimed at highlighting similarities and differences. This approach provides a more complete and contextualised view of axe tombs in the Argaric worlds.

The first section focuses on the detailed spatial analysis of axe tombs with a single buried individual. All of these tombs come from the site of El Argar, where the devised quadrant grid can be implemented (cf. Fig. 2). This selection aims to preserve the individual-grave goods association and to explore their microspatial analysis.

The second section deals with axe tombs, also from El Argar, excluded from the first level of analysis due to problems with their graphics or difficulties in associating grave goods to a single individual in a double or triple burial. Here, the goal is to examine the composition and placement of items in the light of the previous results, paying special attention to possible variations in arrangement.

These two sections provide a detailed overview centred on El Argar. The third level widens the focus by including other funerary contexts with axes from the entire Argaric group, broken down by site to address the diversity of sources. This design collates data on three different scales, offering a complete and comparative reading of the tombs with axes.

Spatial analysis of individual tombs with axes in El Argar

The analysed sample comprises 36 tombs from the site of El Argar (Tab. 1), all of which feature pottery urns as containers. In 32 cases, a single large funerary vessel was used, while in the remaining four, two urns were placed facing each other. In most instances, the placement of the skull suggests that the body was arranged so that the head was positioned at the base of the vessel, with the legs close to

2 The field diaries containing all this data are preserved at the Museo Arqueológico Nacional (Madrid; MAN). All of them are accessible online: <http://www.man.es/man/coleccion/catalogos-tematicos/siret.html> (15.04.2024).

CODE	TYPE	Nº IND	SEX	AGE	1	2	3	4
69	U	1		A (20–30 y)	BZT	2PD-AN, CTA	HAC	
116	U	1	♂	A (30–40 y)		HAC		F4
139	U	1		JUV-A? •	HAC			F1
307	DU	1		JUV/A (> 14 y)	HAC	PÑ-CU PD-AN		
373	U	1		JUV-A? •	PÑ-CU	2PD-AN, CTA, BZT		HAC F4
400	U	1	♂?	A (50–60 y)		2PD-AN	HAC, PÑ-CU	
408	U	1	♂?*	A (40–50 y)	HAC			
434	U	1		JUV (14–20 y)			HAC	F1
479	U	1	♂?	A (> 30 y)				HAC F2
497	DU	1	♂??	–		PD-AN	HAC, PÑ-CU	
513	U	1	♂??	A (20–40 y)	HAC	2PD-AN		PÑ-CU
554	U	1	♂?*	A (20–40 y)	2HAC, PÑ-CU	BZT, CTA		F5
572	U	1		A (20–30 y)				F5
580	U	1	♂*	A (25–30 y)*	PÑ-CU F8	CTA, 5PD-AN, AFI?	HAC	BZT
585	U?	1		A•	F5	HAC		
605	U	1	♂*	A (> 50 y)*		HAC		
632	U	1		A•	F2/7		HAC	
639	DU	1	♂*	A (25–35 y)*	HAC	PÑ-CU		
654	U	1	♂*	A (25–35 y)*	HAC	BZT, PD-AN		
673	U	1	♂*	A (> 50 y)*	HAC, PÑ-CU			
693	U	1		A (30–40 y)*		PD-AN	HAC	PÑ-CU
703	U	1	♂?	A (30–50 y)	HAC	PD-AN BZT		PÑ-CU
725	U	1	♂?	A (40–60 y)		PÑ-CU	HAC, PD-AN	
746	U	1	♂??	A (20–30 y)		2PD-AN, CTA	HAC	
752	U	1		JUV-A? •		PD-AN	HAC	
768	U	1		JUV (14–21 y)*		HAC, 2PD-AN		PÑ-CU, BZT
771	U	1		JUV-A? •	HAC	PÑ-CU 2PD-AN		
784	U	1		A (30–50 y)	F1	HAC	PÑ-CU PD-AN	
799	U	1		JUV-A? •	HAC		PD-AN	
810	U	1		INF I (1–1,5 y)	HAC	CTA, 2PD-AN		F5
816	U	1		A (20–40 y)		AN, 2PD-AN	HAC	PÑ-CU
822	DU	1		–	PÑ-CU	5PD-AN CTA, AFI		HAC F2/7
849	U	1	♂*	JUV (15–18 y)	BZT		HAC PÑ-CU	F1?
862	U	1		A (20–40 y)	HAC	BZT		PÑ-CU
885	U	1	♂?*	A (20–35 y)*		BZT	PÑ-CU, HAC	
952	U	1		A (20–30 y)		CTA	HAC	

the rim (Fig. 3g)[3]. Notably, two unusual cases deviate from this general trend, with the skull found near the mouth of the urn, resulting in the body being positioned ›upside down‹ compared to the prevailing arrangement (tombs 479 and 572).

Regarding the grave goods, all tombs included a single complete axe, with two exceptions. In tomb 554, two axes were deposited, while in tomb 572, only part of the shaft was found, bearing the imprint of the axe[4] and signs of green colouring affecting »wood, bones, and cloth« (Siret/Siret 1890, Pl. 31). Given the absence of evidence of looting, two possibilities are proposed to explain the lack of the axe head: disintegration by taphonomic processes[5] or removal in prehistoric times, without affecting the rest of the tomb. In any case, it appears clear that this tomb was originally associated with a complete axe.

3 In the »Field Diaries« sketches from El Argar and El Oficio, only the skulls are represented, completely omitting the rest of the skeleton. Despite this limitation, the Argaric burial practice, involving the placement of bodies in lateral *decubitus* with limbs flexed, allows for the inference, following anatomical logic, of the position of specific parts of the body within the tomb (Bonora 2021).

4 Here a quote from the »Field Diaries« (MAN inventory number 1944/45/FD00581): »a piece of an axe shaft with its hole and cloth was found« (translated from Spanish by the author).

5 This first option is the one favoured by the Siret brothers: »Dissolved perhaps by acidic waters, the copper salts have strongly impregnated the wood, its preservation being due to the destruction of the metal« (Siret/Siret 1890, 183). »We have already seen that the earth consumed even the copper axes, even though they were quite solid« (Siret/Siret 1890, Pl. 41; translated from Spanish by the author).

5	6	7	8	9	EXT	F
	PÑ-CU		F5			
	PÑ-CU, BZT					
PÑ-CU						
				F2/7		X
						X
BZT		F4				
PÑ-CU						
PÑ-CU	PD-AN			PD-AN		X
					F4	X
	F5					X
				HAC?		
AN	F5					
	PÑ-CU					X
	F4				AFI?	
F2						X
F1	PÑ-CU					X
F4						
						X
F2/7						X
	BZT, PD-AN, CTA, F4					X
F2						X
	PÑ-CU, F2					
F1						
F4						
	PÑ-CU					X
2BZT	F4				F1?	X
BZT	F1					
						X
F5						X
F4						
PÑ-CU		F1				

Tab. 1 Summary information on the spatially analysed axe tombs with a single individual from the site of El Argar. Codes (applied in the Tab. 1–3). TYPE: U Urn; DU Double urn; CM masonry cist; P pit; CR rock-cut; C cist. AGE: A adult; JUV juvenile; INF I infant I; INF II infant II. GRAVE GOODS: HAC axe; F-number of the vessel type (ex. F1); PÑ-CU dagger/knife; PD-AN earring/ring; AN ring; DIL ear plugs; BZT bracelet; CTA beads; F fauna; AFI sharpener. * Information extracted from the review published in Lull et al. 2018; • Age estimate based on container size published in Bonora 2021; ?–?? Degree of uncertainty.

Tab. 1 *Zusammenfassung der Informationen zu den räumlich untersuchten Einzelgräbern mit Beilbeigabe aus El Argar. Codes (aus Tab.1–3): Grabnummer. Typ (TYPE): U Urne; DU Doppelurne; CM gemauertes Steinkistengrab; P Grube; CR in den Fels gehauen; C Steinkistengrab. Alter (AGE): A adult; JUV juvenil; INF I infans I; INF II infans II. Grabbeigaben (GRAVE GOODS): HAC Beil; F-Nummer des Keramiktyps (z. B. F1); PÑ-CU Dolch/Messer; PD-AN Ohrring/Ring; AN Ring; DIL Ohrpflöcke; BZT Armring; CTA Perlen; F Tierknochen; AFI Wetzstein. * Die Daten stammen aus dem Überblick von Lull et al. 2018; • Die Altersschätzung beruht auf der in Bonora 2021 veröffentlichten Gefäßgröße; ?–?? Grad der Unsicherheit.*

The placement of axes in the studied tombs was primarily concentrated in quadrants 1 and 3, occasionally in quadrants 2 and 4, and only in one case in quadrant 9. This trend, rather than reflecting a uniform distribution with axes homogeneously occupying all quadrants, showed that their location was spatially concentrated and proved to be statistically significant[6]. Upon close examination of the graphic representation of the axes (Fig. 3a) around the space occupied by the skull (cf. Fig. 3g), an arc-shaped distribution was observed, indicating an explicit relationship in terms of proximity. Notably, in tombs 479 and possibly 822, this proximity is not evident. If the axehead was close to the individual's head, it can be assumed that the shaft[7] occupied a space between the upper limbs and the trunk of the deceased, being placed either under the individual's back or on top of the torso, reproducing a ›carrying posture‹.

Beyond the axes, this group of tombs also contained six different types of objects: pottery (33 of 36), dagger/knife (30 of 36), earring(s)/ring(s) (21 of 36), fauna[8] (16 of 36), bracelet (15 of 36), and necklace beads (9 of 36). Observing their spatial distribution revealed distinctive patterns for each.

Pottery, though found in several quadrants, significantly clusters in the central area of the tombs[9], corresponding to the location of the torso and the flexed limbs (Fig. 3c). The most prevalent pottery type was the F4, followed by F1 and F5, with documented examples of F2 and F2/7. It does not appear that the pottery type acted as a conditioning criterion for the place occupied by the vessel[10].

The daggers/knives also exhibit a significant tendency[11] to appear in the upper and middle quadrants (1 to 6). Despite their apparent dispersion, a more detailed analysis reveals that the placement of this type of object forms a shape resembling an arc (Fig. 3b). This distribution links the daggers/knives with various parts of the skeleton, such as the skull, upper limbs, back, and chest or waist, depending on the laterality of the skeletons. This suggests two possibilities: either the daggers/knives were held in the hands

6 The goodness-of-fit test reveals significant differences, in this case indicating the association between axes and quadrants 1 to 4 (χ^2: 45.87; p = 6.3664E-07).

7 There are preserved marks on the axes and sufficient wood remains to ensure that this part of the axe was present (see Siret/Siret 1890, 183; Pl. 29–32).

8 While fauna appeared frequently among the analysed tombs, its relative abundance did not receive much attention from the excavators. These finds were only noted under the category of »animal bones« but were not drawn in the sketches, precluding their inclusion in any of the proposed spatial analyses.

9 The goodness-of-fit test reveals significant differences, indicating an association between pottery and the central quadrants 4 to 6 (χ^2: 32.481; p = 0.00016435).

10 The statistical significance test on the contingency Tab. comparing the number of observations in quadrants 4 to 6 according to pottery types does not indicate the association of pottery typology and quadrants (χ^2: 4.5937; p = 0.79999).

11 The goodness-of-fit test shows significant differences indicating the association between daggers/knives and quadrants 1 to 6 (χ^2: 19.028; p = 0.024955).

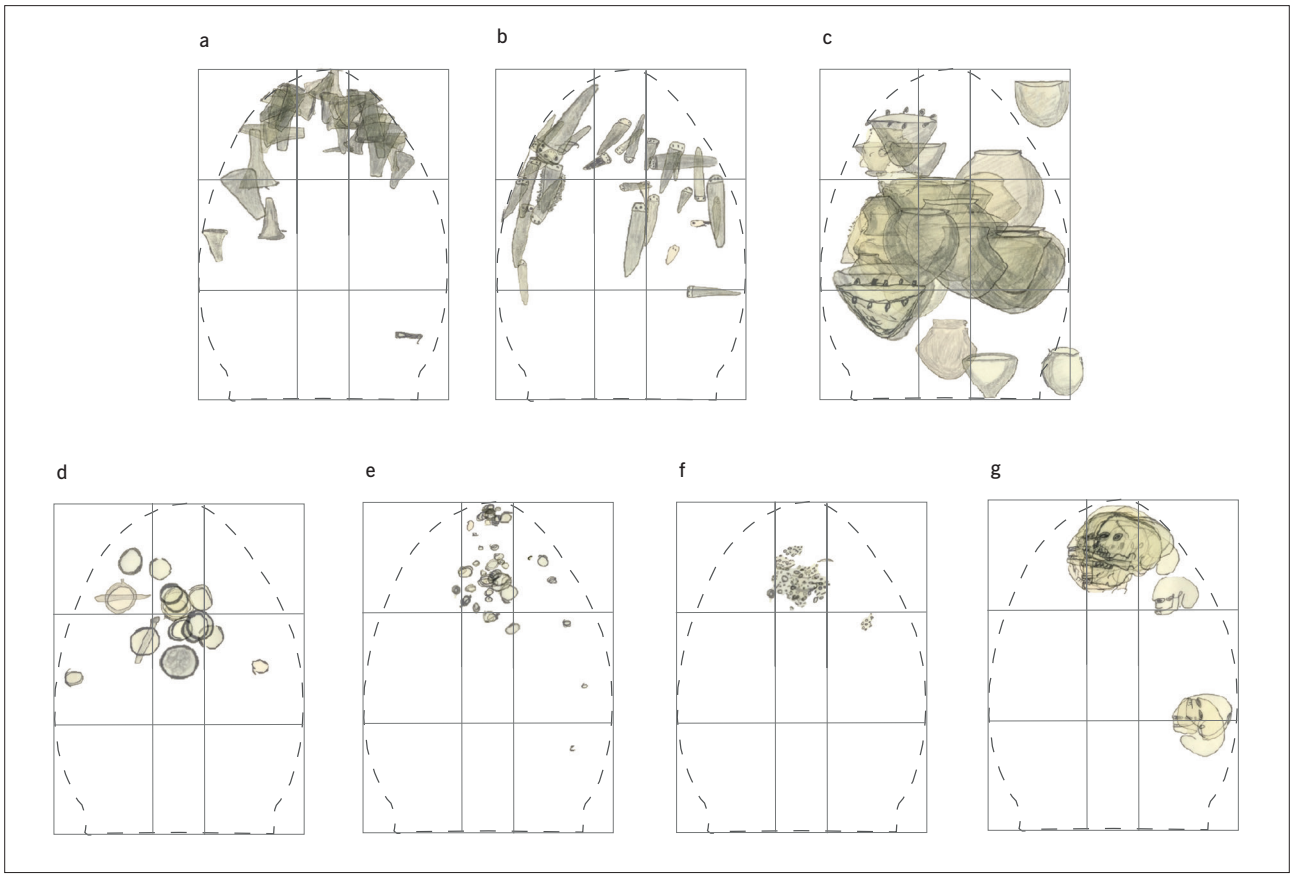

Fig. 3a–g Graph of the distribution of grave goods in the 36 individual tombs of El Argar according to categories. a axe; b dagger/knife; c pottery; d bracelet; e earring/ring; f beads; g skull. The grid of quadrants (cf. Fig. 2) and the shape of the urns are included for a detailed visualisation of the spatial arrangement of the objects.

Abb. 3a–g *Grafische Darstellung der Verteilung der Beigaben in den 36 Einzelgräbern in El Argar nach Fundkategorien. a Beil; b Dolch/Messer; c Keramik; d Armring; e Ohrring/Ring; f Perlen; g Schädel. Zur Veranschaulichung der räumlichen Verteilung der Gegenstände sind das Raster (vgl. Abb. 2) und die Gefäßformen visualisiert.*

by the hilt[12] or carried in places such as the neck, arm, waist, or hip, using a sheath. While the first option is technically possible, there is no mention of it by the original excavators, and it is difficult to imagine that they would not have detected this possibility in any of the numerous tombs with daggers/knives encountered at El Argar. Thus, the second option seems more plausible, as it can easily explain the diversity of spaces occupied by this item type and is consistent with observations of cloth remains in some tombs, indicating that the object was tied or held so close to the body that its contact was fused with part of the textile (Basso 2023).

Earrings/rings were predominantly and significantly[13] found in quadrant 2, although some examples were also located in quadrants 1, 3, 6, and 9 (Fig. 3e). In all cases, these items were found close to the skull. For instance, in tomb 479, one of the cases where the body was located ›upside down,‹ earring(s)/ring(s) also appeared in the same quadrants, indicating a relationship of covariance. Most of these objects functioned as elements that hung around the head of the deceased, either as part of a headdress or as part of a hairstyle. This hypothesis is supported by the observation of pieces of cloth, as in tomb 69, and even hair imprinted in the adjacent sediment or impregnated in the metallic corrosion[14]. On less common occasions, this type of artefact functioned as rings, as they were found inserted into the *phalanges*[15]. Since, following the typical Argaric burial tradition, the hands were left at face level, rings coincide spatially with the place occupied by earrings. This consideration, along with the fact that a detailed study of the workmanship of the earrings and rings is necessary to differentiate them systematically, makes it difficult to distinguish between the two items by spatial analysis alone.

12 As with the axes, there is evidence of the presence of wood and marks on the blade of the daggers/knives certifying that these items were deposited complete.

13 The goodness-of-fit test reveals significant differences indicating an association between earring(s)/ring(s) and quadrant 2 (χ^2: 61.562; p = 6.6978E-10).

14 This can be observed in tomb 166 of El Argar which, although it is not part of our analysis, establishes a reference to the phenomenon just explained (Siret/Siret 1890, 48).

15 This can be observed in tombs 580 (Siret/Siret 1890, Pl. 30) and 816 (»Field Diaries«, MAN inventory number 1944/45/FD00587).

Bracelets were primarily concentrated in quadrants 2 and 5, although there were cases associated with quadrants 1, 4, and 6 (Fig. 3d)[16]. Their distribution suggests a clear relationship with the area where the upper extremities would be expected to be found. This association is supported by observations confirming that the bracelets were inserted into the *ulna* and *radius*[17].

Beads were found almost exclusively in quadrant 2[18] and always formed a coherent grouping with the conformation of one or several necklaces that were placed on the neck and chest of the deceased (Fig. 3f). These necklaces were composed of beads of different materials, highlighting that, in five of the nine tombs, there were pieces made with »boar tusk«[19]. Although the specimen from tomb 554 appears to be a conventional bead with a single hole (Siret/Siret 1890, Pl. 30), the rest of the examples presented peculiar characteristics. As for the piece from tomb 822, little is known due to the altered representation in the field journal[20], however, it is possible that it was similar to the tusks found in tombs 810 and 813, which had multiple holes[21], or to the one found in tomb 580, which presented two hollows at the ends (Siret/Siret 1890, Pl. 23). All these pieces, bearing some resemblance to others such as those made of ivory found in tombs 301 and 579 or the stone with two holes in tomb 154 (Siret/Siret 1890, Pl. 51; 53), were located among other beads next to the skull, suggesting that they could have functioned as spacer beads or even as the central pieces of the necklace.

This analysis cannot be considered complete without addressing an additional aspect that is outside the ›canonical‹ grave goods and is related to the so-called »stones« or »sharpening stone.« In three of the 36 tombs studied – 580, 605, and 822 – the presence of stones was mentioned in the »Field Diaries« as part of the tomb contents. In the first two cases, they were recorded in the journals as »sharpening stone for tool«; however, in the Siret brothers' publication (1890), when the grave goods were detailed, they were not recognised[22]. It is unknown whether this is because they were dismissed as artefacts or because they were not even seen during the inventory. In the case of tomb 605, this element was left on the outside, which could suggest that it is part of a stratum and not of the tomb itself. However, the stone mentioned in tomb 580 was clearly housed inside it, sharing the space with other grave goods in quadrant 2. As for the »stone« from tomb 822, although it is not included in the Siret brothers' publication, the graphic representation of the diary indicates that it was a rectangular item with at least one hole at one end, but probably two[23], and that it was found in quadrant 2. Although the first two cases generate some doubt, the latter case is unequivocally identified as a sharpener, also known as an archer's wristguard.

Examination of other tombs in the El Argar site

At the site of El Argar, 23 additional tombs with axes have been identified, which were excluded from the main analysis due to varied circumstances but whose analysis can still provide relevant data (Tab. 2).

On the one hand, there are those tombs in which the quadrant grid could not be applied in the sketches. In these tombs, making categorical statements is challenging, as some of them lack distinguishable or have missing elements normally present in the sketches (tombs 1, 5, 21, 26, 35, 38, 48, 208, 212, and 245), and in others, their small dimensions did not allow for the distinction of differentiated spatial areas (tombs 387, 427, 732, and 949).

However, in the latter group, probably occupied by children, some observations can be made regarding the arrangement of the objects. The axes were found close to the skull, which is compatible with the hypothesis that they reproduced a carrying and transport posture. The daggers/knives documented in tombs 378 and 949 were located close to the axe. The pottery vessels of tombs 378 and 37 appeared close to the skull, in one case, and in the lower part of the urn, in the other. Additionally, a ›stone‹ was included in tombs 387 and 732, placed close to the skull and the axe. Thus, it seems evident that the objects found in these tombs and their spatial arrangement are consistent with those encountered in the main analysis.

On the other hand, there are the tombs occupied by two skeletons (tombs 189, 538, 609, 813, 940, 958, 968, 977, 984), in which it is possible to implement the analytical grid, but the association of grave goods to the buried remains is difficult. Without delving deep into this problematic issue, the analysis proposed here seeks to compare the distribution of all objects in the tomb as a whole, assuming they all were part of the same set belonging to a single individual, in order to observe possible differentiated patterns[24].

16 The goodness-of-fit test reveals significant differences, in this case in favour of the association between bracelet and quadrants 1 to 6, especially quadrants 2 and 5 of the central area (χ^2: 18.384; p = 0.030972).

17 This can be observed in tombs 69 and 580 (Siret/1890, Pl. 29–30).

18 The goodness-of-fit test reveals significant differences, in this case in favour of the association between the collar and quadrant 2 (χ^2: 38.327; p = 1.52225E-05).

19 While tusks are not the most common type of beads in the funerary context of El Argar, they are not unknown in other tombs. In this case, they stand out for the contrasting fact that this group of tombs presented few cases with necklace beads, despite it being one of the most usual and abundant items in this necropolis – only surpassed by the F5 ceramics, the earrings/rings, and the daggers/knives – and in more than half of them, the boar tusk appeared as a distinctive element.

20 The graphic record is altered by the ink on the other side of the page in the field notebook with the inventory reference in the MAN: 1944/45/FD00587.

21 In the case of tomb 810, it even preserved some silver earrings attached to some of the orifices.

22 Only information on the stone from tomb 580 is in the section on the »objects found outside the tombs,« where it is considered to be a diorite cobble with three tarnished surface facets. The authors confirm that this tool was found in the burial (Siret/Siret 1890, Pl. 23,21).

23 It is difficult to be sure of the existence of a second hole at the other end due to the aforementioned circumstance of the ink.

24 The only object which has not been included and compared is the awl, found in three of these tombs (189, 813, and 940), given that it was an object exclusively associated with women and, consequently, it is possible to rule out their inclusion as part of the set of objects related with the axe.

CODE	TYPE	Nº IND	SEX	AGE	GRAVE GOODS
Tombs with problems in the quality of the graphic information					
1	U	–	–	–	HAC, F4
5	U	1	♂	A (> 20 y)	HAC, PÑ-CU, F2
26	U	–	–	–	HAC, F8
35	U	1	♂*	JUV (12–16 a)	HAC, PÑ-CU, BZT, PD-AN, F4, F?
38	U	–	–	–	HAC, PÑ-CU, BZT, 2PD-AN, F4
48	U	–	♂*	A (> 20 y)*	HAC, PÑ-CU, BZT, PD-AN, F5
208	U	–	–	–	HAC, PÑ-CU, 2PD-AN, F5
212	U	1	–	A (30–50 y)	HAC, PÑ-CU
387	P	1	–	INF •	HAC, PÑ-CU, AFI?, F2, F
427	P	1	–	INF •	HAC
732	P	1	–	INF •	HAC, AFI?, F4, F
949	U	1	–	INF •	HAC, PÑ-CU
Double tombs					
21	U	2	♂/♀	A (40–60 y)/A (40–60 y)	HAC, 2PÑ-CU, BZT, CTA, F4, F8, F
189	U	2	–/–	–/–	HAC, PÑ-CU, PZ, 3PD-AN, CTA, F4, F2/7, F8
245	U	2	♂/♀	A (> 50 y)/A (30–40 y)	HAC, PÑ-CU, PZ, BZT, 3PD-AN, CTA, ivory comb, F1, F3, F
538	U	2	♂?/♀*	A (20–30 y)/A (20–35 y)*	HAC, PÑ-CU, CTA, F2, F5
609	U	2	♂?/♀*	A (> 50 y)/A (25–30 y)*	HAC, PÑ-CU, CTA, F2, F8, F
813	U	2	–/–	A (30–50 y)/–	HAC, 3PÑ-CU, PZ, BZT, 3PD-AN, CTA, F4, F
940	DU	2	–/–	–/–	HAC, PÑ-CU, PZ, 2PD-AN, F4, F5, F8
958	U	2	–/–	A (30–50 y)/–	HAC, PÑ-CU, BZT, 3PD-AN, F4, F8, F
968	U	2	♂??/–	A (40–60 y)/–	HAC, BZT, PD-AN, F4, F8
977	U	2	♂?/♀?	A (> 20 y)/A (20–40 y)	HAC, PÑ-CU, BZT, 4PD-AN, CTA, F5, F8, F
984	U	2	♂/♀	A (30–40 y)/A (> 50 y)	HAC, F2, F2/7, F8, F

Tab. 2 Summary information on the axe tombs with peculiarities of the El Argar site (see codes in Tab. 1).

Tab. 2 *Zusammenfassung der Beilgräber mit Besonderheiten vom Fundort El Argar (Legende siehe Tab. 1).*

In this case, the grid analysis indicates that the placement of the items was similar to that observed in the tombs with a single individual (Fig. 4). The axes were mostly associated with the upper quadrants, drawing an arch around the skull. Here as well, two cases of ›upside down‹ tombs were encountered in which axes were located in quadrant 9 (Fig. 4a [red]). The daggers were found predominantly in the centre of the container in quadrant 5. This pattern is entirely coherent with that observed in the previous analysis (Fig. 4c–f [red]); however, it should be noted that some of the encountered daggers could not have belonged to the grave goods of the individual with the axe. For example, in tomb 813, three daggers/knives were encountered. Nor is it possible to point out at a glance the differences in the distribution of ceramics, bracelets, earrings/rings, or necklace beads (see Fig. 4c–f [red]).

The overall similitude in the arrangement of grave goods in individual and double tombs is further reinforced by statistical tests[25], indicating that the object distributions in the group of individual and double tombs cannot be significantly differentiated. In summary, everything suggests that, despite the particularity inherent in the spatial arrangement of objects in double tombs, the objects were placed in a similar manner to that observed in the individual tombs, which makes it possible to consider that they followed a common ritual pattern.

25 These tests were carried out on the distributions of axes, daggers/knives, pottery, and bracelets, as they had sufficient frequencies (> 5). Significance tests results: axes: χ^2: 6.4519; p= 0.16785; daggers/knives: χ^2: 7.4354; p= 0.19022; pottery: χ^2: 11.5; p= 0.24301; bracelets: χ^2: 5.5238; p= 0.23764.

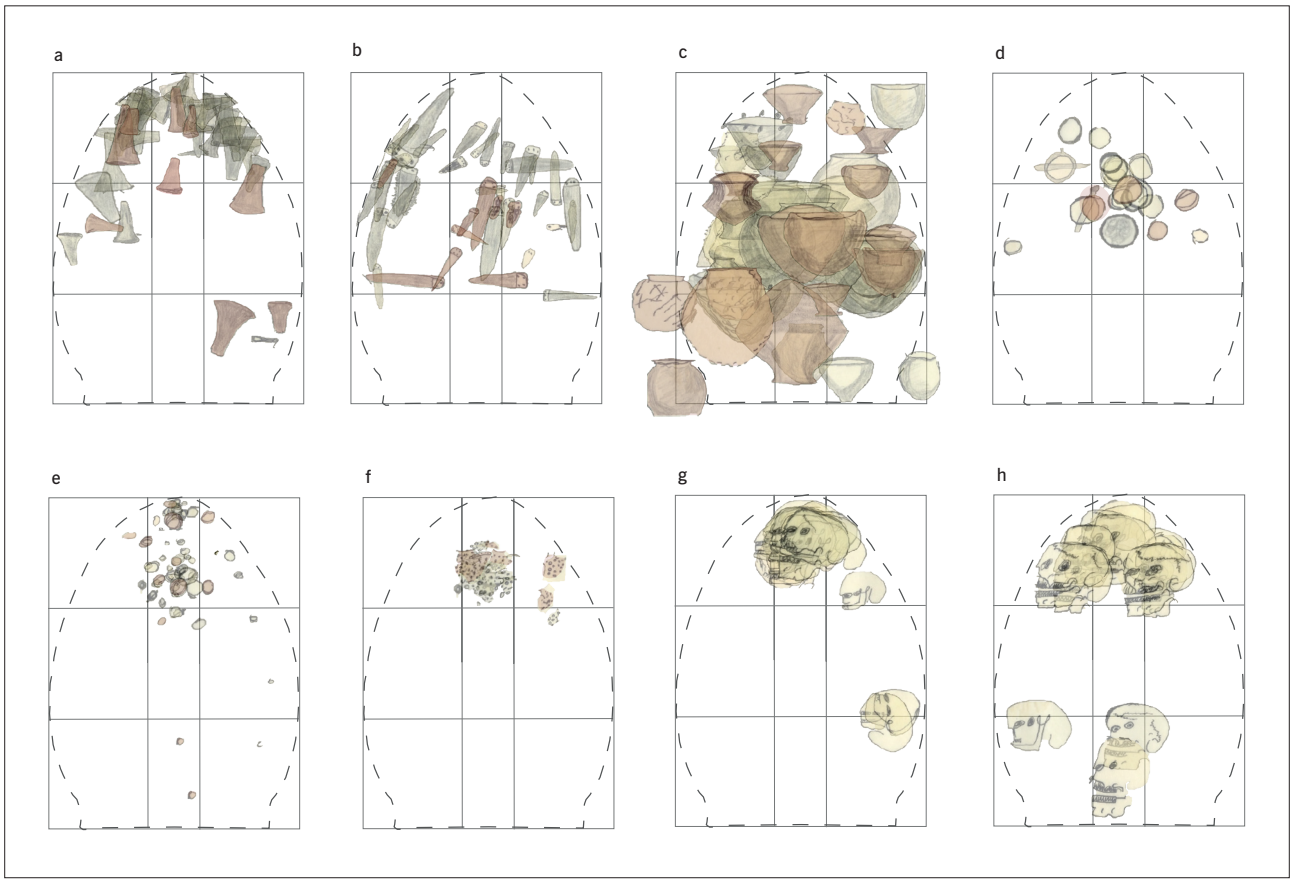

Fig. 4a–h Graph comparing the distribution of grave goods in the tombs with one individual and tombs with two individuals from El Argar. In red are the items from the double tombs. The categories used are the same as in Fig. 3. a axe; b dagger/knife; c pottery; d bracelet; e earring/ring; f beads. A specific category is added for the skulls in the double tombs (h), allowing comparison with those from the single tombs (g).

Abb. 4a–h *Vergleichsdarstellung der Verteilung der Beigaben in Gräbern mit einem oder zwei Individuen in El Argar. In Rot die Objekte aus den Doppelgräbern. Die Fundkategorien entsprechen weitgehend denen aus Abb. 3. a Beil; b Dolch/Messer; c Keramik; d Armring; e Ohrring/Ring; f Perlen. Eine eigene Kategorie wird für die Schädel aus den Doppelgräbern (h) angegeben, die einen Vergleich mit den Schädeln aus den Einzelgräbern (g) erlauben.*

Unravelling funerary contexts with axes in the Argaric world

In the Argaric funerary record beyond the site of El Argar, just over twenty axe tombs have been identified, distributed across sites in the present-day Spanish provinces of Almería, Murcia, Granada, and Alicante (Tab. 3). The documentation on these finds is completely heterogeneous. In most cases, it is possible to recover data on the contents of the tombs and to reconstruct their composition with a fair degree of certainty, although doubts may persist about such details as pottery typology or the material of some earrings/rings. However, finding data or illustrations detailing the placement of the objects in the tombs has proven much more difficult. Accordingly, this will be done in the following pages site by site.

El Oficio (Grima, Cuevas del Almanzora, Almería)

In El Oficio, also excavated and documented by the Flores-Siret[26] tandem at the end of the 19th century, seven axe tombs were documented, one of them a double burial (cf. Tab. 3, OF-37-72-205-209-238-244-278). At a first glance, the distribution of objects in the El Oficio tombs appears very different from that observed in El Argar (cf. Fig. 4). However, this can be quite easily explained if it is considered that one of the seven analysed tombs was a cist with two individuals and that four out of the six single burials (tombs 205, 238, 244, and 278) were ›upside down‹ tombs (Fig. 5h). This phenomenon is significant in its concurrence in El Oficio, and its effects are felt in a number of ways.

Perhaps the most obvious is related to the earrings/rings, which were found in close proximity to the skull – in this case, in quadrants 7 to 9 (Fig. 5e); the opposite quadrants to that of El Argar (cf. Fig. 4e). The same occurs with axes, which again were found close to the skull, with the singular

26 The »Field Diaries« compiled during the excavation of El Oficio by the Flores family under the direction of the Siret brothers are also accessible and can be consulted through the reference indicated in footnote 2.

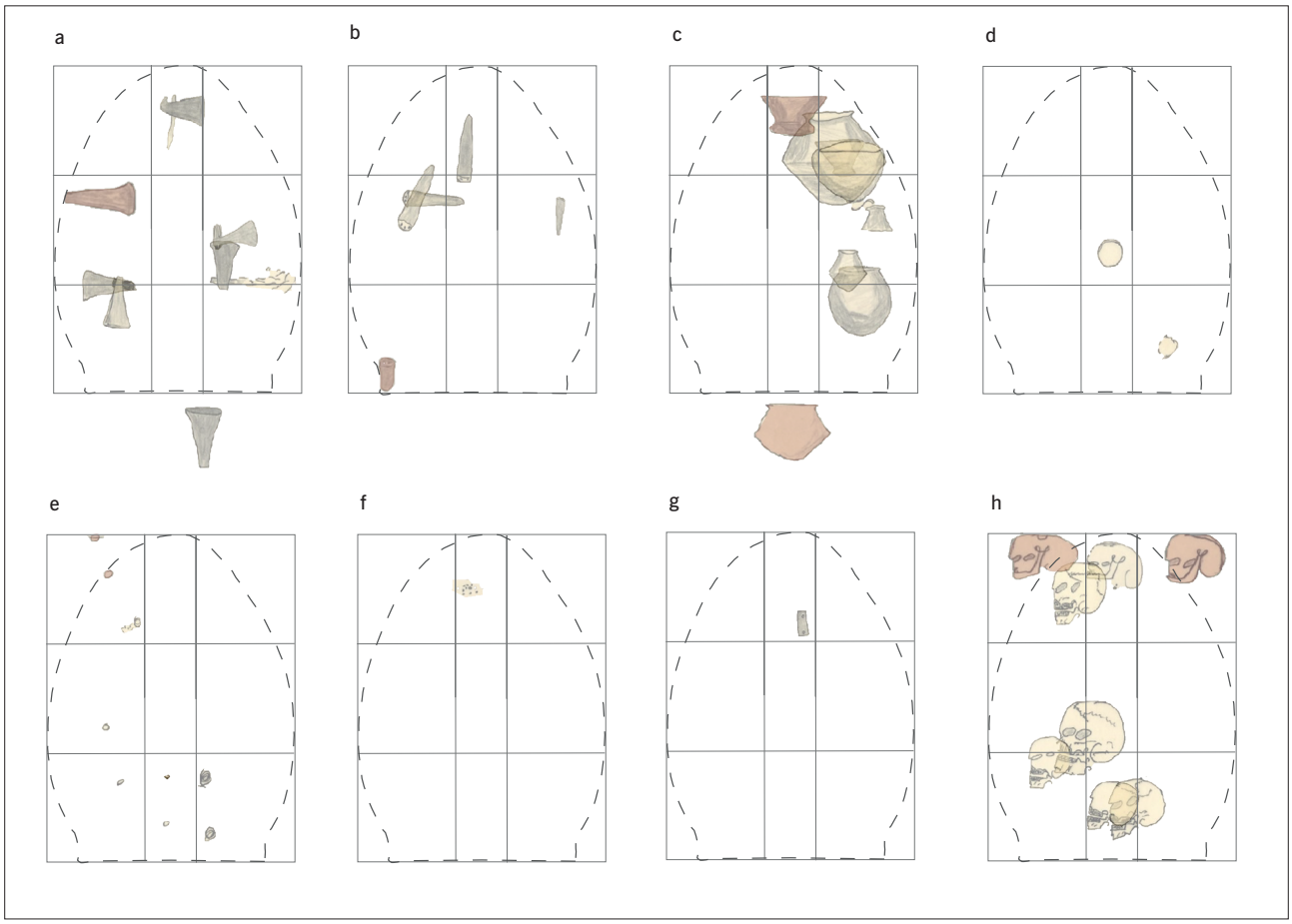

Fig. 5a–h Graph of the distribution of grave goods found at El Oficio in the six tombs with one individual and one tomb with two individuals, arranged according to categories. a axe; b dagger/knife; c pottery; d bracelet; e earring/ring; f beads; g wristguard; h skull. In red are the items from the double tomb.

Abb. 5a–h *Grafische Darstellung der Verteilung der Beigaben in den sechs Einzelgräbern und dem einen Doppelgrab aus El Oficio nach Fundkategorien. a Beil; b Dolch/Messer; c Keramik; d Armring; e Ohrring/Ring; f Perlen; g Armschutzplatte; h Schädel. In Rot die Objekte aus dem Doppelgrab.*

exception of tomb 278, where an axe was found together with a pottery vessel and a dagger, and tomb 37, where the axe was located close to the mouth of the urn, outside the container. Thus, in most of the tombs of El Oficio, the axes were found in quadrants 6 or 7 (Fig. 5a), compared to quadrants 1 to 4 typical in El Argar. The distribution of daggers/knives and pottery is less affected by the phenomenon just described, as they tended, as in El Argar, towards the centre of the container (see Fig. 5b–c). In tomb 205, a singular object stands out, commonly known as an archer wristguard, which, nonetheless, functioned as a sharpener.

La Bastida (Totana, Murcia)

In La Bastida, as a result of numerous excavation campaigns from the end of the 19th century to the present day, six axe tombs have been documented, including two double burials and one considered a cenotaph. The three individual tombs, originating from different excavation campaigns led by various teams, present a diverse record. The unnumbered tomb excavated by Cuadrado provides information, although spatial disposition details are unknown (Tab. 3, BA-C). Tomb 1, excavated by Flores-Siret, has graphic documentation (Tab. 3, BA-S-1) showing a burial with an axe close to the skull, consistent with previous observations. Tomb 37, excavated in the mid-20th century by the team from the Seminario de Historia Primitiva del Hombre; Univ. Complutense de Madrid (Tab. 3, BAO-37), lacks graphic support illustrating its arrangement. However, it is possible to reconstruct it based on descriptive details[27]:

»In the interior, in the eastern part and close to the mouth [of the urn], there were two vessels on top of each other. [...] In the interior of this vessel, full of earth, an awl

27 It is true that tomb 37 is not free of uncertainty, given the presence of an axe and an awl and a single male occupant; this association has only been documented in double tombs with a man and a woman, a fact that suggests that this was indeed a misinterpreted double tomb.

CODE	SITE	TYPE	Nº IND	SEX	AGE	GRAVE GOODS
37	OF	U	1	–	A	HAC, CTA, F4, F8, F
72	OF	C	2	–/–	–/–	HAC, PÑ-CU, PZ, 2PD-AN, F5, F8
205	OF	U	1	–	–	HAC, PÑ, AFI
209	OF	U	1	–	A	HAC, 2PD-AN
238	OF	U	1	♂	A (40–60 y)	HAC, PÑ-CU, BZT, 2PD-AN, F5
244	OF	U	1	–	–	HAC, PÑ-CU, BZT, 2PD-AN, F7
278	OF	U	1	♂?	A (20–40 y)	HAC, PÑ-CU, 2PD-AN, F5
1	BA-S	U	1	–	–	HAC, F
	BA-C	U	1	♂	A	HAC, PÑ-CU, PD-AN, F5
37	BA-O	U	1?	–	JUV (12–14 y)	HAC, (PZ?), BZT, 4PD-AN, 2AN, DIL, CTA, F2/7, F3, F5, F
52	BA-O	U	2	–/–	–/–	HAC, 2PÑ-CU, 3PD-AN, CTA, F1, F2, F8
13	BA	U	0	–	–	HAC, F5, F7, F
18	BA	U	2	♂/♂	A (22–29 y)/A (18–21 y)	HAC, PÑ-CU, PD-AN, F2, F5, F
A	LC	CM	1?	–	–	HAC, PÑ-CU, BZT, 6PD-AN, FX?
B	LC	C	–	–	–	HAC, 4PD-AN, CTA?, FX?
68	FA	C	1	♂	A (20–30 y)	HAC PÑ-CU, BZT, PD-AN, CTA, F4, F4, F5, F7
2	TR	P	1	♂	A (24 y)	HAC, CTA?, F2?
17	MM	DU	2	–/–	A (> 35 y)/A 25–30 y)	HAC, PÑ-CU, CTA, F8, F
18	CE	CR	3	♂/♀/♀	A (30–40 y)/A 25–35 y)/ A (40–44 y)	HAC, PÑ-CU, PZ, BZT, CTA, F2, F2, F3, F5, F
121	CA	CR	2	♂/–	A (27–29 y)/INF II (4 y)	HAC, PÑ, 2BZT, 3PD-AN, CTA, F3, F4, F4, F7, F
2	IF	¿	–	–	–	HAC, F5
	SC	C	1?	–	–	HAC, PÑ-CU, F1, F2, F2, F5

Tab. 3 Summary information on axe tombs found at other Argaric sites (see codes in Tab. 1).

Tab. 3 *Zusammenfassung der Beilgräber von anderen Fundorten der El-Argar-Kultur (Legende siehe Tab. 1).*

with a wooden handle was encountered. [...] At the bottom [lay] the skull; and on top of it, a small axe with the edge upwards. [...] Next to the right ear, an earring and several pieces of a very oxidised bronze spiral were found, as well as the remains of a silver ring. The right arm had a bronze bracelet. [...] One of the fingers appeared with a cylindrical silver ring« (Martínez et al. 1947, 100–101; translated from Spanish by the author).

The same situation applies to Tomb 52 (Tab. 3, BAO-52), excavated by the same team and occupied by two individuals. This tomb preserves a detailed description and even some pictures (Lull et al. 2016, Annex 8, 1049–1052).

»The skulls were piled one on top of the other. [...] Close to the mouth [of the urn], there was a bowl [...] and a vessel. In it, two bronze daggers appeared along with a ring of the same material; beneath the lower skull, a flat bronze axe, a silver ring, and 43 intact necklace beads, as well as some broken ones« (Martínez et al. 1947, 103–104; translated from Spanish by the author).

Thanks to its detailed register, it is possible to link the axe of the double tomb 18 (Tab. 3, BA-18), excavated by the ASOME – UAB (Arqueoecologia Social Mediterrània at the Autonomous University of Barcelona) team, with a specific individual. The axe appeared on the back of the deceased together with a meat offering, while a carinated vessel placed as an external grave good could not be decisively associated with any of the buried bodies (Lull et al. 2016, 49). Finally, tomb 13 (Tab. 3, BA-13), which, owing to the typology and size of the urn, resembled the tomb of a child, contained no corpse. In the exterior, it was accompanied by a carinated vessel, a chalice, faunal remains, and a copper axe (Lull et al. 2016, 49–50). It appears that this cenotaph was accompanied by grave goods similar to those placed next to the male individual in tomb 18 of the same site.

Laderas del Castillo (Callosa de Segura, Alicante)

In the excavation works and the publication by J. Furgús in 1937, two axe burials from the site of Laderas del Castillo are documented. The descriptions provided in the text allow for the reconstruction, albeit with some uncertainties, of the composition of their grave goods, and they offer insights regarding their placement:

»It [the burial] consisted of a small black earthen vessel placed, as was customary, beside the head of the deceased; two large silver spirals and two silver rings, a massive silver bracelet, and two gold rings, as well as a dagger (0.10 m long) and copper axe, which were crossed one on top of the other« (Furgús 1937, 65; translated from Spanish by the author) (Tab. 3, LC-A).

»One of the findings in this place stands out for having a vessel of unusual shape and also one copper axe, another axe of diorite, three spirals and a silver ring, and about six dozen ivory buttons, painted red and in the shape of a cone or small pyramid. As the tomb was quite disturbed, due to the movement of the slabs and the collapse of the one that served as a cover, it is probable that, among other objects, a spiral and a silver ring were lost, as they were usually found in pairs« (Furgús 1937, 66; translated from Spanish by the author) (Tab. 3, LC-B).

In the case of the second burial (LC-B), it is important to note that the tomb exhibited signs of destruction and alteration. Some scholars have suggested that certain objects that were initially included, such as the diorite axe, might not have been part of the original burial assemblage (López 2006, 34; Lull et al. 2018). If this description holds true, it would represent a unique and remarkable case, particularly considering the distinctive material of the second axe.

Fuente Álamo (Cuevas del Almanzora, Almería)

At the Fuente Álamo site, despite the discovery of more than one hundred tombs, only one yielded an axe: tomb 68, identified as a cist with a single individual (Tab. 3, FA-68) (Schubart 2012, 132–133). The skull was located in what would correspond to quadrant 3, as per our analytical framework, and the rest of the body was positioned in a lateral *decubitus* with the lower limbs hyperflexed, maintaining complete anatomical connection. According to the excavators, a dagger/knife was found »approximately in the centre of the tomb« (quadrant 4), the axe was positioned »under the skull« (quadrant 3), a silver earring/ring was discovered »above the jaw« (quadrant 2), and a silver bracelet was placed in quadrant 5. Additionally, four pottery vessels were included, three of which were found close to the feet and skull (quadrants 1, 7, and 9). In conclusion, the detailed description of this tomb clearly highlights its similarities with those known from El Argar.

Castellón Alto (Galera, Granada)

A single axe tomb (tomb 121) was discovered at the Castellón Alto site; it contained the partially mummified remains of two individuals buried in an artificial rock-cut (Tab. 3, CA-121). Although the association of the objects to each of the individuals is not entirely explicit, it is clear that the axe (quadrant 3), along with a dagger, silver earrings/rings (quadrant 3), and some beads (quadrant 3), belonged to the adult male. On the other hand, the vessels (quadrants 1 and 4) and faunal remains could not be ascribed to any individual and might have been shared[28].

Cerro de la Encina (Monachil, Granada)

At the Cerro de la Encina site, an axe was discovered in a tomb occupied by three individuals (Tab. 3, CE-18). In this tomb, the last individual to be interred, a male, had a silver bracelet inserted in his *ulna* and *radius*, two vessels located at his feet, and a possible third one close to the skull, which was covered by a copper axe (Aranda et al. 2008, 229–232). A single necklace bead might have been associated with this individual as well. Conversely, a dagger, an awl, a small pottery vessel, and a faunal remain would have been deposited as grave goods in the previous burials.

Madres Mercedarias (Lorca, Murcia)

In the excavation of the Madres Mercedarias convent, a double tomb containing an axe was found (Tab. 3, MM-17). Not much is known about the placement of the objects and the possible association of each one of them with the buried individuals. Based on the observations made so far in this work, it would be expected that the axe, the dagger (which was found resting on the vertebrae), the necklace beads, and the animal bones would have been part of the object assemblage corresponding to the individual who was buried last. However, it has been suggested that the vessel, which had a broken rim, was part of the first burial, which was displaced, and its bones disarticulated, when the second individual was deposited, as a broken rim-sherd of the pot appeared in a nearby area (Martínez/Ponce 2002; Lull et al. 2018, 236 footnote 10).

Santa Catalina del Monte (Verdolay, Murcia)

There is news of a fortuitous discovery of a cist tomb with an axe at the site of Monte Santa Catalina (Tab. 3, SC), which the landowner handed over to archaeologists researching in the area. The grave goods of the tomb consisted of four ceramic vessels, the axe, and a dagger, although the details of their placement are completely unknown (Muñoz 1985).

Terrera del Reloj (Dehesas de Guadix, Granada)

In tomb 2 of Terrera del Reloj, another axe tomb was documented, in this case belonging to a single individual and accompanied by a pottery vessel and a necklace; regrettably, no concrete information about the precise location of the grave goods could be obtained (Tab. 3, TR-2) (Dorado/Molina 2018).

Ifre (Mazarrón, Murcia)

To conclude this overview, it is possible to include here, with some reservations, a tomb from the site of Ifre, of which very little is known, which would have contained an axe and a vessel (Tab. 3, IF-2) (Siret/Siret 1890, 121).

28 Cf. repository of AD&D 4D/R. Munoz: Digitalización 3D del Hombre de Galera (momia). Castellon Alto|Galera|Granada|Spain|Europe, <https://zenodo.org/records/3484620> (06.05.2024).

Discussion and final conclusions

The axe tombs analysed in this study can be understood as acts of composition. Composition, in this context, is presented as a process opposed to the mere accumulation of elements in space. Rather, the key element of composition lies in the careful selection and arrangement of appropriate objects so that the empty space facilitates »reading.« The act of composing arises from the intention to communicate something in a coherent and aesthetic way. The communicative intentionality focused especially on the axe, which emerges as a significant element shared by all the tombs and their respective male occupants. The choice of the axe as an essential component suggests the existence of deep symbolic connotations, where the distinction between tool and weapon could provide crucial clues to its meaning in a worldview that transcends multiple Argaric sites. This pattern, recognised in much of the Argaric territory, suggests that those identified as axemen shared the interests and material conditions of a social group that was recognised by their contemporaries beyond death.

Similarity in the selection of object repertoires

The analyses developed throughout this work support the idea of an intentional selection of grave goods from the tombs observed. This implies that some Argaric objects were chosen and placed repeatedly, while others were excluded. In the case of the axe tombs, the similarity in the grave goods assemblages is remarkably high. The individual tombs reviewed had such similar assemblages that they cannot be significantly differentiated[29], and they were even identical in some cases[30]. This relation of similarity can even be traced in the grave goods of the double tombs and the triple tomb, despite reservations about the unequivocal assignment of objects. In other words, a burial with an axe attracted other grave goods that have been shown to be similar in dozens of tombs on the same site and in some twenty tombs spread over a dozen Argaric sites.

In the context of the slight variations observed, it is pertinent to highlight two aspects that have gone unnoticed but may merit further attention in future research as distinctive elements. First, the repetition of »boar bones or tusks« within the bead assemblage is noteworthy. In addition to the elements found in the tombs of El Argar, similar pieces can be found in the grave goods of BAO-37, where two »ivory plaques« with four holes, an »ivory hoop,« and two wild boar tusks were found (Martínez et al. 1947, Fig. 13). The persistent association of ivory plates or elements turned into beads or spacers, especially linked to tombs of individuals with axes, could support the consideration of the »ivory buttons« discovered in tomb LC-B as part of a necklace or pectoral (López 2006).

Secondly, it is worth highlighting the presence of lithic elements in the tombs. In addition to the observations made in the tombs of El Argar, a lithic element was found in tomb 205 of El Oficio (OF-205) and, possibly, another one in tomb 37 of La Bastida (BAO-37; Lull et al. 2016, 165). These elements share the characteristic of being tools for forging or sharpening, and they appeared accompanying the axe or the dagger/knife, suggesting that they are part of the same kit.

Both elements – the boar tusks and the lithic elements – are not alien to the general record of Argaric tombs, but their concentration around axe tombs seems to be recurrent in several settlements and is thus worthy of further exploration.

Similarity in placement of objects

The similarity between the tombs containing axes goes beyond the mere presence or absence of certain objects, as a repetition in the arrangement of their elements has been identified. The recurrence in the disposition of objects suggests an intentional pattern that links these elements to specific parts of the body of the deceased. This pattern seems to be aimed at creating a funerary setting where the buried body acts and is represented as a bearer. The close connection between the elements of adornment, the tools or weapons, and the deceased seems evident in light of the analysis developed here. The exception to this, perhaps, were the vessels, which, together with the faunal remains, were more related to some part of the funerary ritual or/and to the giving of offerings, and were placed according to other criteria.

The importance of respecting and following the agreed rule(s) when composing the tomb is indirectly evident in the group of axe tombs that were ›upside down‹. Although the inverted placement of the body in the urn, with the skull in the opening of the vessel, is not completely unknown in the Argaric funerary record, it is unusual and stands out especially in this group of tombs. These tombs offer the opportunity to observe how, with the variation in the position of the body, the arrangement of the objects also changed, but the pattern, although inverted, continued to be respected. A notable example is found in the tombs 238 and 244 of El Oficio, which were ›upside down‹ and presented an identical composition to tombs 400 and 768 of El Argar. Put differently, in essence the tombs were structurally and compositionally very similar, despite the difference in the placement of the body.

The pattern identified in the tombs extended beyond the limits of a single settlement, suggesting the existence of a shared ideology based on the existence of a funerary coherence, the communication of meanings, and the persistence of tradition. This point acquires an essential relevance because it serves as the point of convergence between the abstract realm of ideas and the material manifestations that

29 Results of the significance test on the contingency table of the items of each tomb with a single individual: χ^2: 203.84; p= 1.

30 The presence of grave goods containing the same items has been noted on three occasions: (1) one tomb at La Bastida (BAC) and two at El Argar (752 and 784); (2) two tombs at El Oficio (238 and 244) and two at El Argar (400 and 768); and one tomb at El Oficio (278) and one at El Argar (771).

are the focus of archaeology. At this juncture, shared beliefs and concepts about death, rooted in the intangible sphere of ideas, intertwine with the concrete materiality of the funerary. It is at this crossroads between the abstract and the material that a fuller understanding of the symbolic complexity of funerary practices is forged and where the deeper meaning that axes, as recurring elements, may have had in the shared worldview of the Argaric people can be explored.

Site-to-site variability

Axe tombs are spread over several Argaric sites, but the finds are not evenly distributed among them. El Argar stands out due to the significant number of axe tombs (59), in stark contrast to other Argaric sites, where only 22 axes have been discovered, spread between ten settlements (cf. Fig. 1). At first, it might seem that this notable difference is due to the quantity and quality of the finds at El Argar, which has almost 1000 excavated tombs, in comparison with other settlements such as Ifre or Santa Catalina, whose discoveries are close to fortuitous and poorly documented. However, among the sites studied, there are several with a significant volume of funerary finds, such as El Oficio and La Bastida, with almost 300 tombs each, and Fuente Álamo and Castellón Alto, with more than 100 each. These settlements, despite having a representative sample, do not present as many axe tombs, indicating that this difference cannot be attributed solely to the limitations of the quality and quantity of the archaeological record. In other words, beyond the discrepancies found in the archaeological record, it is evident that additional factors influenced the prevalence of axe-centred tombs, particularly notable at El Argar. This underscores the necessity for deeper exploration into the socio-political determinants shaping the significance and distribution of these tombs.

Meaning of axes in tombs

The common denominator between these tombs centred on the male character of the individual buried and the presence of an axe as an accompaniment. The inclusion of the axe in a grave meant that the object went beyond its practical use; by entering the grave, it acquired a symbolism that transcended its practical function, which could be in direct relation to its meaning. The crucial distinction between considering axes as tools or as weapons emerges as a cardinal point in the understanding of these tombs, and clarifying this duality proves to be a crucial step in refining the interpretation.

In the absence of specific studies addressing the analysis of a significant number of axes, and taking into account aspects such as their handle, size, or use-wear markers, determining whether the axe was a tool or weapon remains open to assumption. However, the evidence in the current archaeological record suggests that one of the two options is more likely and consistent.

On the one hand, axes could have served as cutting tools for woodworking (Sanahuja 2007, 198), a fact possibly linked to economic activities that gained importance from 1800 cal BC, coinciding with a period of reported high demand for agricultural land (Castro et al. 1999, 270). This hypothesis finds support in the type of handle observed in some axes, such as the one found in grave 121 at Castellón Alto, which resembles an adze more than a conventional axe (Molina et al. 2003) and the lack of positive evidence (use-wear analysis or anthropological samples with signs of axe marks) to support its use as a weapon (Brandherm et al. 2011, 607). However, if the appearance of the axe were solely linked to the exploitation of new lands and the obtaining of wood, one would expect to find a greater number throughout the Argaric territory, as well as a probable increase in the number of stone axes, neither of which is observed in the current record. Moreover, the absence of evidence is not a sufficient certainty or logical argument that can negate another; it merely attests that there is not yet sufficient information.

On the other hand, axes may have been used as specialised tools for violence, serving as weapons alongside halberds and swords. Tombs containing these three types of items, consistently associated with male figures, exhibit remarkably similar compositions (Bonora 2021). Consequently, the shared internal structure of these tombs indirectly supports the proposition that axes were perceived as weapons (Lull et al. 2018). This reasoning links their bearers with the potential for coercion and violence, essential elements in the formation and maintenance of a state society, which seem to have played an important role from 1800 cal BC onwards, coinciding with the appearance of other elements in the funerary record associated with the exercise of power, such as the sword and diadem (Lull et al. 2021).

Thus, various indications in the archaeological record point towards increasing political control and military apparatus in which axes, and their bearers, may have played a significant role. In this sense, the concentration of axe-bearing figures at the El Argar site, in particular, can be interpreted as a symptom of increasing political centralisation in the region (Lull et al. 2018, 241). This phenomenon suggests an evolution in social and political organisation, where the capacity for coercion and violence, represented by axes and other similar objects, becomes a fundamental means for maintaining and institutionalising power (Lull et al. 2011).

Social figures and shared ideology

In conclusion, the evidence just reviewed regarding the selection and placement of objects in the Argaric axe tombs suggests that there was a set of shared ideas that guided their composition. This is an important historical consideration, as it reveals that the Argaric sites and their inhabitants not only shared objects such as the axe, which archaeology can trace and classify as belonging to the same »material culture«, but that there were shared ideas that materialised in the tombs.

These ideas, linked to the axe-bearing male bodies buried in different areas of the Argaric territory, could point to the presence of a group of interest. This group, composed of individuals with similar material conditions, was united through representation in their tombs as a distinctive social

figure. Although this group of axemen was strongly centred on the site of El Argar, their distinctive social figure was widespread and can be recognised through their pattern at other Argaric sites. This would imply that a person from an Argaric settlement attending a funeral in another settlement would have been able to recognise and establish relations with many of the actions and symbols present in the funerary ritual, discerning the social role of the person buried through the material composition of the tomb and the shared ideology.

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Bronze and Iron Age axe-hafting techniques in Central and South-Eastern Europe. A study of the archaeological visibility of prehistoric technological innovations

Oliver Dietrich

Zusammenfassung

Bronze- und eisenzeitliche Schäftungstechniken von Äxten und Beilen in Mittel- und Südosteuropa: Eine Untersuchung der archäologischen Sichtbarkeit technologischer Innovationen in der Vorgeschichte

Äxte und Beile können zahlreiche Funktionen besitzen: als Werkzeuge, Waffen, Statusobjekte, Gerätegeld oder Votive. Gelegentlich sind sie multifunktional und umfassen mehrere dieser Bedeutungsebenen. Häufig sind sie eng mit sozialen Praktiken verbunden. Nach einer knappen Schilderung der wichtigsten bronzezeitlichen Innovationen im Bereich von Äxten und Beilen nutzt der vorliegende Beitrag mittel- und südosteuropäische Funde, um zu verdeutlichen, was die enge Verbindung mit sozialen Praktiken für die archäologische Sichtbarkeit dieser Innovationslinien bedeutet. Zwei Thesen werden diskutiert: (1) Die bronzezeitliche Axtentwicklung spiegelt die Suche nach einer Methode zur sicheren Verbindung von metallener Klinge und hölzernem Schaft wider. Die Lösungen für dieses Problem sind nicht rein technischer Natur, sondern immer auch kulturell geprägt. (2) Die archäologische Sichtbarkeit dieser Entwicklung wird durch die sozialen Praktiken, deren Teil Äxte und Beile sein können, und hier insbesondere die intentionelle Niederlegung, verstärkt oder erschwert.

Schlagwörter Bronzezeit, Südosteuropa, Beil, Tüllenbeil, Schäftungstechnik

Summary

Axes can be tools, weapons, symbols of prestige and power, money, votives, and more. Sometimes they fulfil a number of these roles at the same time. Axes are deeply entangled with social concepts, and they form part of social practices. After a short characterisation of the main lines of Bronze Age axe innovations, the present paper uses finds from Central and South-Eastern Europe to show what the social dimensions of axes and their different roles in social practices mean for the archaeological visibility and interpretability of the history of Bronze Age technological innovations. Two main points will be made: (1) The development of Bronze Age axe types is a quest for a technical method to securely attach axeheads to their wooden shaft. This quest follows different culturally determined trajectories in different regions. (2) The archaeological visibility of these trajectories is impaired or enhanced by social practices associated with metal axes, particularly intentional and selective deposition.

Keywords Bronze Age, South-Eastern Europe, axe, socketed axe, hafting technique

Bronze Age innovations between technological evolution and cultural choices

Neolithic and Chalcolithic stone axes are highly efficient tools. Experimental studies have shown an efficacy for woodworking comparable to that of steel axes (Roberts/Ottaway 2003). In this respect, the transition to metal axes is not necessarily self-explanatory. But two main advantages of metal over stone can be identified. (1) Metal objects can be recycled, and new things can be made from scrap (Hansen 2011, 276–277)[1]. (2) Casting in moulds combined with forging allows the production of innovative objects in complex shapes. Copper and, subsequently, bronze axe blades can be made much thinner than stone axes, which are always distinctly wedge-shaped, thus limiting the depth of their penetration into the material being processed. However, the new thin axe blades also produce a problem: the secure connection with the shaft. Thin metal blades are hard to attach securely to wooden shafts and are driven deeper into them with each blow, eventually splitting them and rendering the tool unusable (Harrison 1926, 219; Kibbert 1980, 187–188).

The entire Bronze Age axe development reflects the search for a solution to this technical problem. The simplest one would have been the shafthole axe, a design that has

1 Recycling of polished stone axes is known of course during the whole Neolithic and Chalcolithic, but technologically limited to making ever smaller objects out of fragments or used tools.

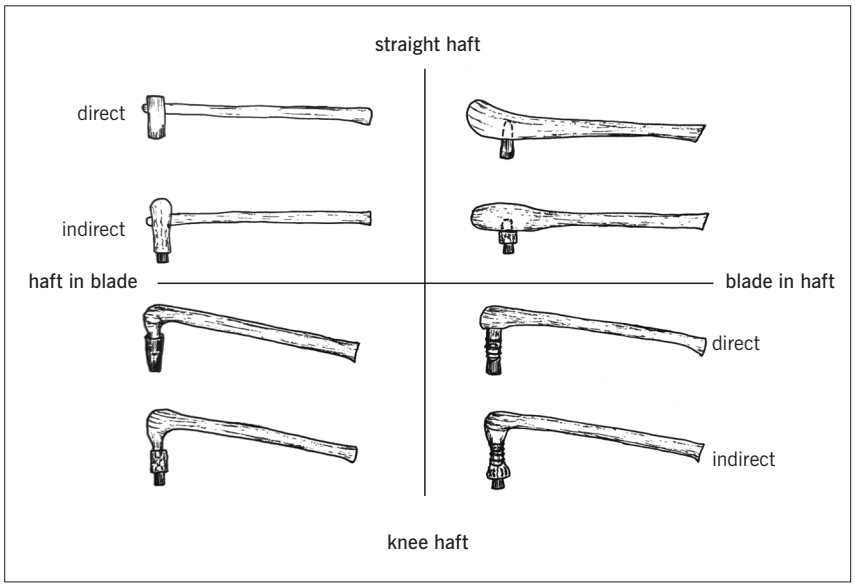

Fig. 1 Possibilities of hafting an axehead. On a first level, short shafts for one-handed and long ones for two-handed use can be differentiated. On a second level, hafting techniques can be differentiated by the type of shaft used – straight shafts or curved knee shafts. The axes/adzes can either be fastened in the shaft, or the shaft is introduced into the perforated axehead. Already from the Neolithic, there is a basic distinction between direct and indirect hafting with a sleeve.

Abb. 1 *Möglichkeiten der Schäftung von Beil- und Axtklingen. Zunächst lassen sich kurze Schäfte für einhändige und lange Schäfte für zweihändige Nutzung unterscheiden. Auf einer zweiten Ebene können die Schäftungstechniken nach der Form des Schafts unterschieden werden – gerade Schäfte oder gebogene Knieschäfte. Die Äxte/Beile/Dechsel können entweder im Holm befestigt werden, oder der Schaft wird in das Schaftloch einer Axt gesteckt. Bereits seit der Jungsteinzeit sind direkte Schäftungen im Holm und indirekte über ein Zwischenfutter geläufig.*

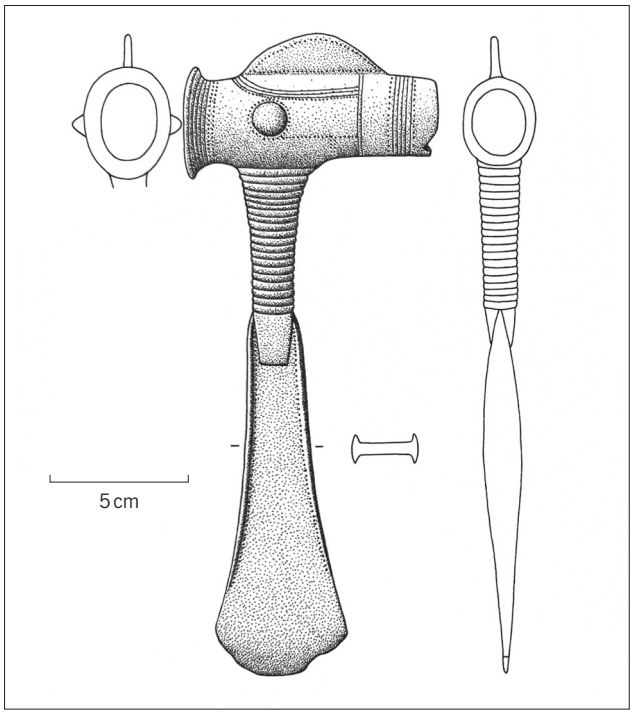

Fig. 2 The bronze axe from Przećmino, West Pomeranian voivodeship (Poland), is one of the rare recreations of hafting techniques involving metal. A flanged axehead is fixed to a solid metal forked-peg with an imitation of the binding. The forked-peg construction is more resistant compared to blades embedded directly into a straight wooden shaft.

Abb. 2 *Die bronzene Prunkaxt aus Przećmino, Woj. Westpommern (Polen), ist eine seltene metallische Umsetzung von bronzezeitlichen Schäftungstechniken. Ein Randleistenbeil ist in einem Gabelschaft befestigt, die Verschnürung ist durch Rippen angegeben. Die Gabelschäftung ist widerstandsfähiger als eine direkte Schäftung im Holm.*

been known for stone axes since the Neolithic. However, the problem of the wedge-like thickening body is present here, too; the shaft hole creates a weak spot for heavy work, and the material expenditure is significantly bigger than with flat axe blades. Shafthole axes are therefore primarily weapons in many regions (»battleaxes«) and were richly decorated as objects of prestige. During the Early Bronze Age, flat axes in the tradition of Neolithic tools still predominate. The first attempt at using the advantages of metal are flanges on the sides of the axe, meant to provide a better hold by wedging the axe head into the wooden shaft. Then three distinct Middle to Late Bronze Age innovations appear: palstaves with flanges and stops, winged axes with metal »flaps« that can be fastened around a shaft, and socketed axes. They fully exploit the plastic possibilities of metal as a material for the first time.

It might be helpful to shortly discuss the basic possibilities of hafting axeheads. J. Winiger (1981, 162–163) differentiated on a first level between short shafts for one-handed and long ones for two-handed use. Both can be used as axes (Axt- or Beilschäftung in German) and adzes (Dechselschäftung in German). Following Winiger, axes are predominately used for cutting trees, chopping wood, and beveling, whereas adzes imply tasks like shaping, levelling, or gouging. This distinction is not absolute, though, as ethnographic evidence implies that adzes can be used for major woodworking such as cutting trees, too; tool choice/hafting technique seems to some degree to be culturally determined (e.g., Hampton 1999, 63–76; 82–88). On a second level, hafting techniques can be differentiated by the type of shaft used – straight shafts or curved knee shafts (Fig. 1). The axes/adzes can either be fastened in the shaft, or the shaft is introduced into the perforated axehead.

Already from the Neolithic, there is a basic distinction between direct and indirect hafting with a sleeve (Winiger 1981). The sleeve has the advantage of adding weight and acting as a buffer, compensating to some degree the blows that are too hard. Both techniques are attested for Bronze Age axes[2], although direct hafting seems to be predominant[3].

2 Dietrich 2010 for an overview on sleeves made from bronze or wood for socketed axes.

3 E.g., Winiger 1981; Spennemann 1985; Taylor 2001, 219–222; Trebsche 2002, with references; and below.

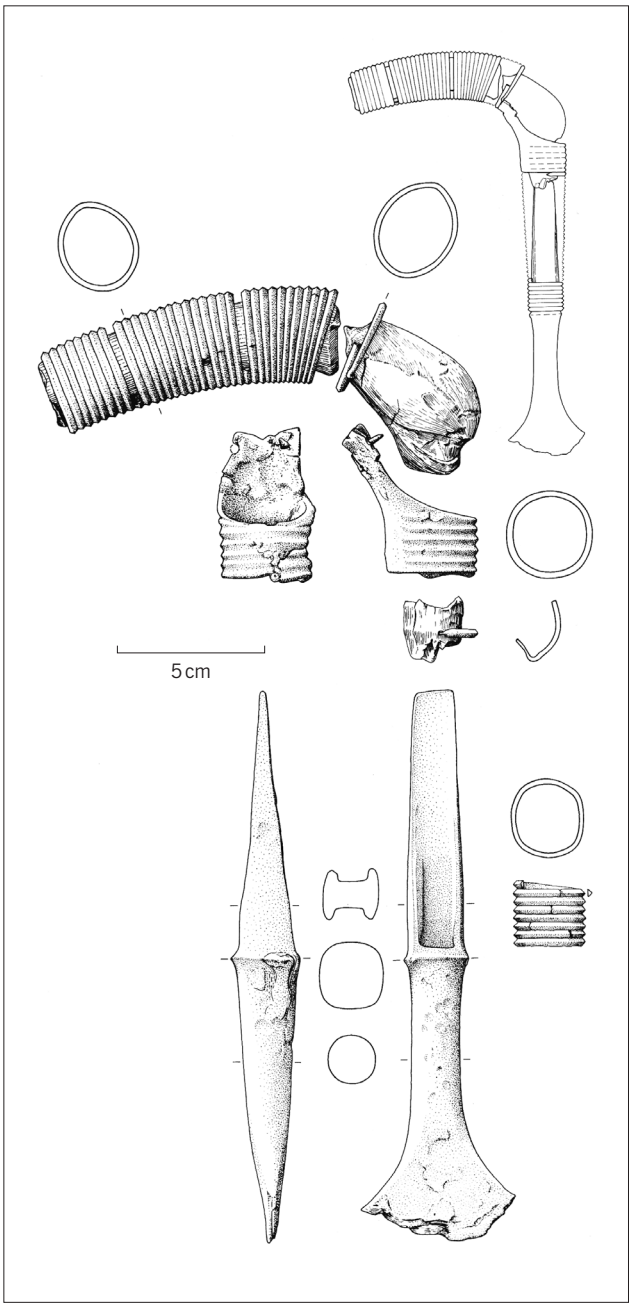

Fig. 3 A palstave from Keitum, Sylt, Nordfriesland district (Germany), illustrates the use of a metal collar to prevent breakage of the forked peg. The ribs of the collar are reminiscent of the metal wire or cord used for this purpose for other axeheads.

Abb. 3 *Ein Absatzbeil aus Keitum, Sylt, Lkr. Nordfriesland, zeigt die Verwendung einer Metallmanschette, um das Brechen der Gabelschäftung zu verhindern. Die Rippen der Manschette stellen die sonst übliche Verschnürung dar.*

Knee hafts with forked pegs were regularly used for flat axes, for palstaves with ridge stops, and for winged axeheads, as the preserved wooden examples[4] and the rare recreations of such hafting techniques involving metal show. Most impressive is a flanged axehead fixed to a solid metal forked-peg with an imitation of the binding from Przećmino (Prettmin), West Pomeranian voivodeship, in Poland (Fig. 2)[5]. The forked-peg construction is more resistant compared to blades embedded directly into a straight wooden shaft. The axeheads were successively adapted to provide a better hold: Flanges prevent movements of the axehead in vertical (axe) or horizontal (adze) direction; the ridge stops of palstaves are meant to counter the force driving the axe into the base of the forked support. Winged axes are the attempt to find a solution to both problems by bending strong metal ›flaps‹ around the peg. Additional firm lacing has the function of strengthening the transition between the forked peg and the shaft. This lacing can be replaced by metal wire or (probably slightly later) by a solid metal collar[6] that fits exactly at the point where the axe could have been driven into the shaft or would have split the peg (Fig. 3)[7]. A most intriguing experiment in this regard comes from the »surroundings of Racibórz (Ratibor)«, Silesian voivodeship, Poland (Kuśnierz 1998, 69 Nr. 570; Pl. 26,570). A palstave ends in a tang that has two ribbed metal collars, the upper one featuring a loop, giving the impression of an imitation of a socketed axe (Fig. 4). However, the lacing, wire, wing, or collar construction does not completely eliminate the basic problem. This is only achieved by another hafting method: Directly hafted socketed axes no longer require a forked peg to hold the axehead in place. They mark a final break with Neolithic technology[8]. Socketed axes also need less raw material and can therefore be regarded as a peak of Bronze Age axe technology.

It would nevertheless be wrong to assume a linear evolutionary development from one form to the other. On the contrary, there are persistent regional preferences for certain technical solutions. During the older Urnfield period, socketed axes predominate in east-central Europe and South-Eastern Europe, while Central Europe is characterised by winged axes; in the Northern German lowlands, Scandinavia, and the Baltic States, but also in Western Europe, palstaves with ridge stops are mainly used (Sprockhoff 1941, 103–106, Fig. 81–82; v. Brunn 1968, 79; Hansen 1994, 158 Fig. 87). Socketed axes start to appear in Northern Europe in larger numbers during Period III (Aner 1962), they become common in the following Period IV and pre-

4 To cite just a few examples: Flat axes: Niederlauterbach, Pfaffenhofen district; Höhengau, Amberg-Sulzbach district; Unterbrunnham, Traunstein district (Pászthory/Mayer 1998, Pl. 18,250; 20,295–296); palstaves: Keitum, Sylt, Nordfriesland district (Aner/Kersten 1979, 90; Pl. 42,2713B); winged axes: Mörigen, Canton of Bern, Switzerland (Ischer 1928, 110–111 Pl. 13,2; Fig. 98).

5 Sprockhoff 1941, 107 Fig. 69,7; Szpunar 1987, 77 Nr. 458; Pl. 26,458. Another example comes from Krottenthal, Dingolfing-Landau district (Holste 1941, 161 Pl. 23,1). In the case of the flanged axe with bronze shaft from the Melz II hoard (Schoknecht 1972, 237–239 Fig. 179g), the axe is added onto a shafthole-construction without indications of hafting in a forked peg. The hafting, as such, is comparable to the axehead from Naumburg, Burgenlandkreis district (Schwarz 2004) or the Pădureni, Monteoru or Apa-Nehoiu type axes of the Carpathian Basin (Vulpe 1970, 42–48; 53–56).

6 E.g., Broholm 1934, Fig. 1a (Guldhøj, Sjælland, Denmark); Sprockhoff 1941, Fig. 83,1 (Drönhorst, Stormarn district); 84,2 (Ostenfeld, Nordfriesland district); Aner/Kersten 1979, 90 Pl. 42,2713B (Keitum, Sylt, Nordfriesland district).

7 Sprockhoff 1941, 106–107.

8 Winiger 1981, 167–169 Fig. 5.

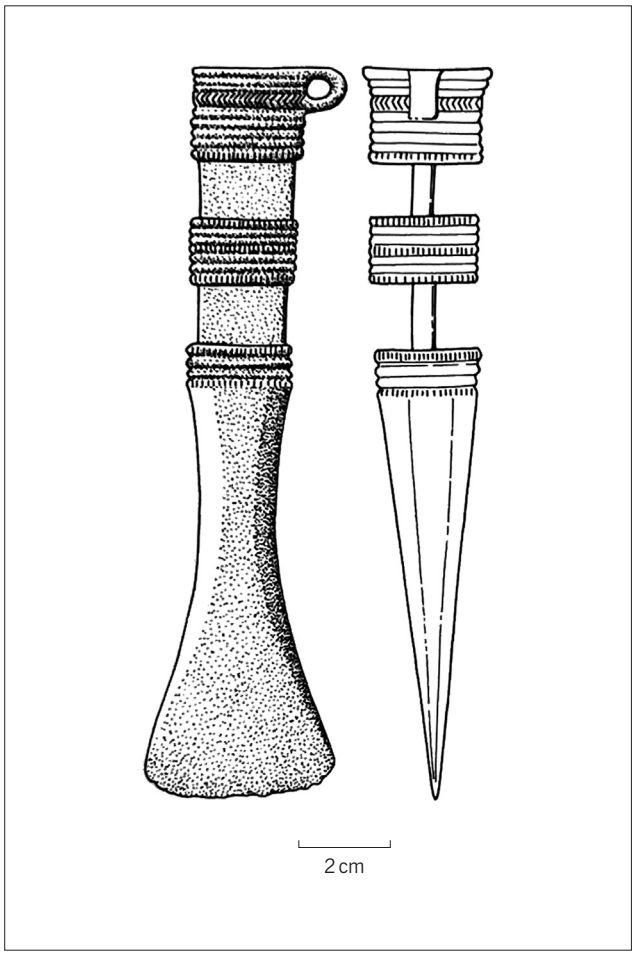

Fig. 4 Racibórz, Silesian voivodeship (Poland). A palstave ends in a tang that has two ribbed metal collars, the upper one featuring a loop, giving the impression of an imitation of a socketed axe.

Abb. 4 *Racibórz, Woj. Schlesien (Polen). Ein Absatzbeil endet in einer Griffangel mit zwei aufgeschobenen Manschetten. Die obere weist eine Öse auf, sodass der Fund wie die Imitation eines Tüllenbeils wirkt.*

dominate from there on (Baudou 1953; Baudou 1960, 16–26). In continental Western Europe they appear in many regions during the transition from the Late Bronze Age to the Early Iron Age (Briard 1965; Schmidt/Burgess 1981; Eogan 2000), while in the Eastern Alpine region winged axes remain more common throughout (Mayer 1977; Pászthory/Mayer 1998). Technologies are not purely about functionality; they are often also culturally determined. Change is facilitated or hindered by intellectual concepts of what works. Particularly the development, acceptance, and rejection of the concept of socketed axes offers insights into such innovation and adaptation processes.

The first socketed axes in Europe

Socketed axes are usually considered a Late Bronze Age invention in Central and South-Eastern Europe (v. Brunn 1968, 83–85; 147–148). The technique of hollow casting was available long before this point in time, though. Socketed spearheads and socketed chisels are attested already in the Early Bronze Age[9]. The earliest currently known evidence for socketed chisels consists of two moulds from a settlement of the Makó Culture at Üllő, Pest county (Hungary; Kővári/Patay 2005, 113 Fig. 9,1–3; 17,1; 121–122 Fig. 11,4–6; 20,1). They indicate a local production as early as in the middle of the 3rd millennium BC.

There are typological indications for some kind of connection between early socketed chisels and socketed axes. Of particular interest is a group of socketed chisels that have been called the »Bullendorf type« (Dietrich 2010a) after a hoard from Lower Austria (David 2002, 450 Nr. A23; Pl. 196). These socketed chisels have an elongated, slender shape, a mostly symmetrically cut out and ribbed mouth and occur between Bz A2 and B2 (Fig. 5; List 1). The form of the mouth area and the slim overall shape are very similar to some early socketed axes that have so far been dated to the beginning of the Urnfield period, best exemplified by

Find list 1: »Bullendorf type chisels«

1.	**Balatonakali**	Veszprém county, Hungary. Hoard, Kisapostag Culture/Apa-Hajdúsámson horizon. David 2002, 463; Pl. 273,4.
2.	**Bullendorf**	Lower Austria, Austria. Hoard, Únětice Culture (Bz A2). David 2002, 450; Pl. 196,4.
3.	**Căuaş III**	Satu Mare county, Romania. Hoard, phase 2. Bălan 2009, 33 Nr. 11.
4.	**Derşida**	Sălaj county, Romania. Mould, settlement, Wietenberg (II) Culture (Bz B). Bălan 2009, 3; 34 Nr. 23.
5.	**Nagybátony**	Nógrád county, Hungary. Cemetery, Piliny Culture (Bz B1). Hänsel 1968, 72; Pl. 40,10.
6.	**Pecica**	Arad county, Romania. Mould, settlement of the Mureş Culture. Bălan 2009, 3; 35 Nr. 41.
7.	**Rimetea**	Alba county, Romania. Hoard, Early Bronze Age. Bălan 2009, 3; 35 Nr. 44.
8.	**Sălacea**	Bihor county, Romania. Settlement of the Otomani (II) Culture (Bz B1–2). Bălan 2009, 3; 35 Nr. 50.
9.	**Sântion**	Bihor county, Romania. Mould, settlement of the Otomani Culture. Bălan 2009, 3; 35 Nr. 54.
10.	**Vedrovice**	Znojmo district, Czech Republic. Grave, Únětice Culture (Bz A2). Říhovský 1992, 267 Nr. 1188; Pl. 74,1188.86C.

9 Hänsel 1968, 71–72; 74; Primas 1977, 166–168 Fig. 2; Găvan/Lie 2020.

10 The axes of type A2 after Dietrich 2021, 195–204.

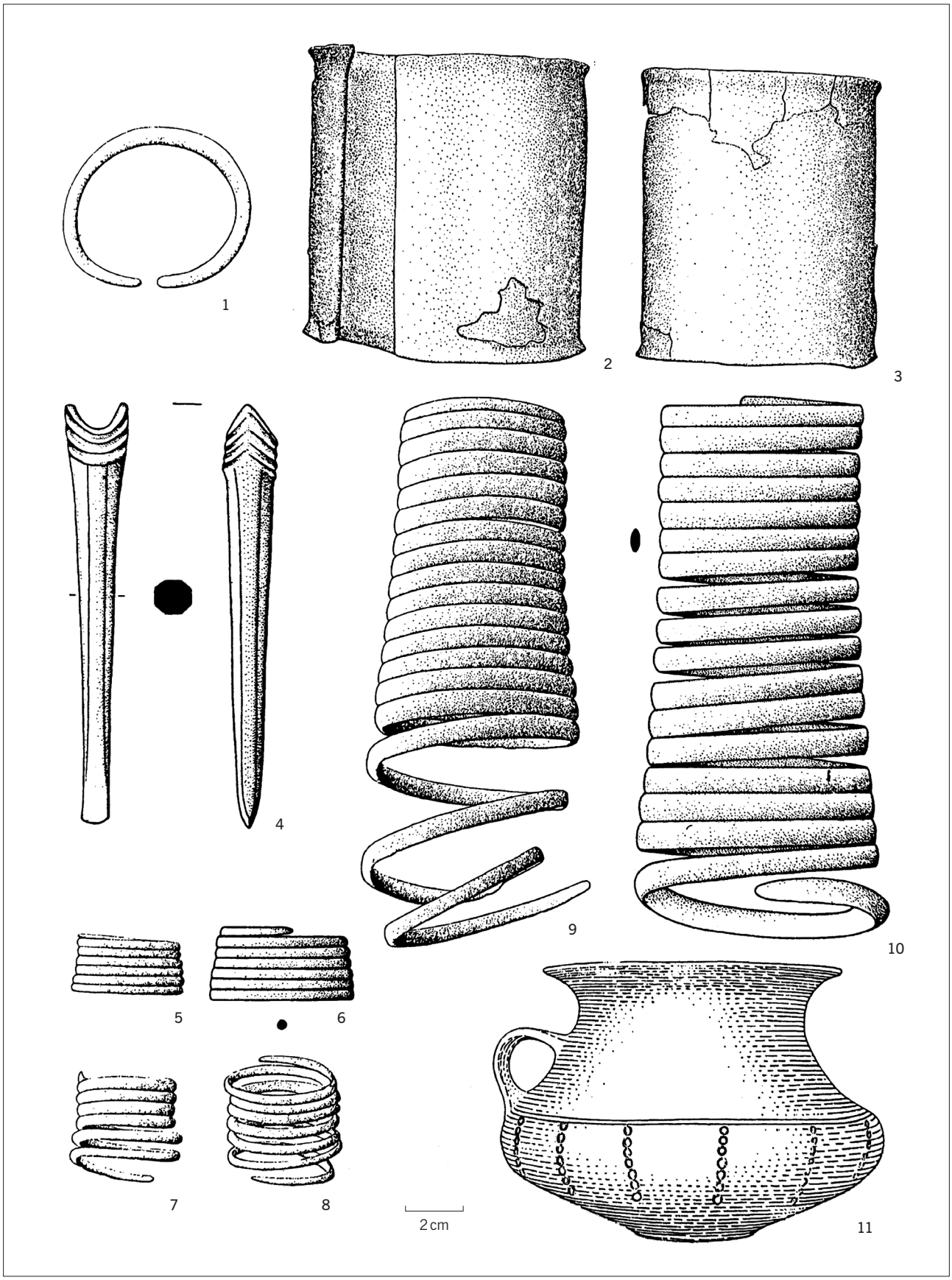

Fig. 5 The hoard from Bullendorf, Lower Austria (Austria), including an early socketed chisel. Socketed chisels of the »Bullendorf type« have an elongated, slender shape, a mostly symmetrically cut out and ribbed mouth and occur between Bz A2 and B2. The form of the mouth area and the slim overall shape are very similar to some early socketed axes of the Carpathian Basin that have so far been dated to the beginning of the Urnfield period.

Abb. 5 *Der Hort von Bullendorf, Niederösterreich (Österreich), enthält auch einen frühen Tüllenmeißel. Meißel des Typs Bullendorf haben eine langgestreckte, schlanke Gesamtform und eine symmetrisch ausgeschnittene Mündung. Sie treten zwischen Bz A2 und B2 auf. Die Gesamtform und die Ausprägung der Mündung ähneln frühen Tüllenbeilen des Karpatenbeckens, die bislang an den Beginn der Urnenfelderzeit datiert wurden.*

Fig. 6 A socketed axe from the hoard Rozavlea III, Maramureş county (Romania). Axes of type A2 after Dietrich (2021, 195–204) are typologically very similar to the »Bullendorf type« chisels dating between Bz A2 and B2. This similarity could speak in favour of an earlier date for this type of socketed axe (Muzeul Judeţean de Istorie şi Arheologie Baia Mare, 691).

Abb. 6 *Tüllenbeil aus dem Hort Rozavlea III, Kr. Maramureş (Rumänien). Beile vom Typ A2 nach Dietrich (2021, 195–204) ähneln typologisch den Meißeln vom »Typ Bullendorf«, die zwischen Bz A2 und Bz B2 datieren. Die formale Ähnlichkeit könnte für eine frühere Datierung der Tüllenbeile sprechen (Muzeul Judeţean de Istorie şi Arheologie Baia Mare, 691).*

a large series of axes from the same mould in the hoard Rozavlea III , Maramureş county, from Romania (Fig. 6)[10].

The fact that socketed axes in South-Eastern Europe were seen as a purely Late Bronze Age phenomenon for a long time is due to the close connection between this tool type and a specific type of transmission: hoard finds. The Bronze Age metal cycle (Fig. 7) runs in principle from the raw material through casting, use, repair, and reuse to re-melting (Fontijn 2002, 33; 248–250 Fig. 13,1; Hansen 2011, 277–278 Fig. 2). There are only three options for exiting this cycle: loss, disposal, or intentional deposition in graves or hoards. In the last three decades, a new perspective on hoard finds has been established. Numerous works have been able to prove that the vast majority of hoards are not scrap metal stores of dealers or things hidden in crisis situations, but evidence of a structured, religiously and socially motivated phenomenon[11]. The creation of hoards is, not unlike grave inventories, based on time-specific selection processes and rules[12]. Not everything is hoarded, and not everything can be mixed and matched with everything else (»selective deposition«)[13]. The condition – e.g., the degree of fragmentation of objects – is also subject to such rules.

What this means for the preservation of metalwork becomes immediately clear if we look at the finds of socketed axes in Romania as a case study (Dietrich 2021). Almost 70 % of the 3743 socketed axes have been handed down as part of hoards, another c. 6 % belong to uncertain hoard finds (Dietrich 2021, 39–42). Individual and settlement finds are completely underrepresented. If socketed axes were not selected for hoarding by Bronze Age communities, re-melting would have led to a loss of more than 75 % of the finds we know of[14]. Metalwork not intentionally selected for deposition may become fairly invisible; chance finds from settlements may be all that remains[15].

So far, the earliest appearance of socketed axes has been associated with the Ópályi-Uriu-Domăneşti hoarding horizon or Bz D (Dietrich 2015). However, if one takes a closer look at the find contexts, doubts arise. Relatively few hoards have survived from the Early and Middle Bronze Age of the Carpatho-Danubian region compared to

11 E.g., v. Brunn 1980; Hansen 1994; Sommerfeld 1994; Hänsel/Hänsel 1997; Fontijn 2002 (with bibliography).
12 Proven and described in a trans-European perspective by Hansen 1994.
13 See Needham 1989; Ţârlea 2008, with further references.
14 Many of the 598 axes with unknown find circumstances are likely from hoards, while many of the 211 single finds likely represent depositions: Dietrich 2021a.
15 See also Hänsel/Medović 1995; Dietrich/Ailincăi 2012.

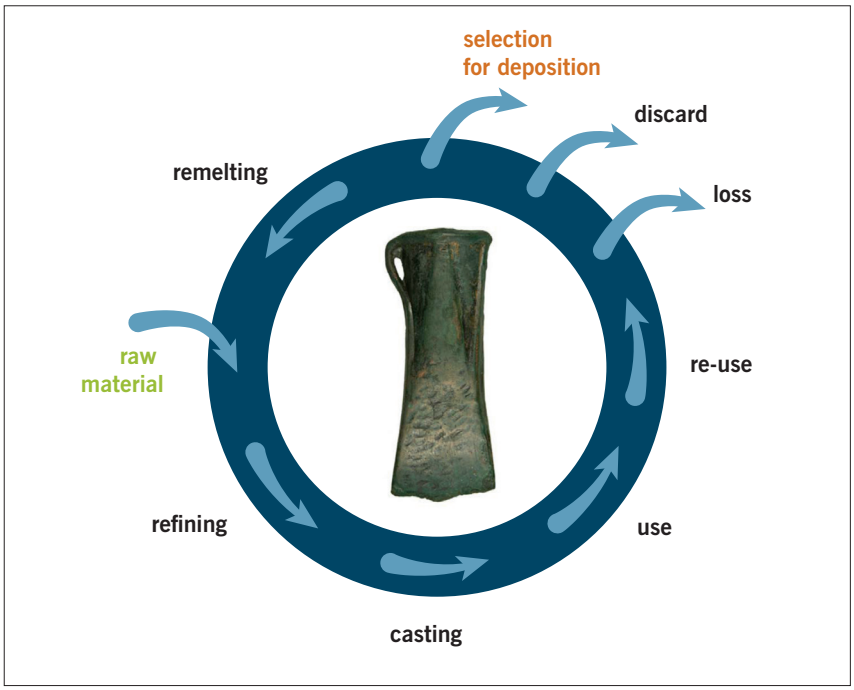

Fig. 7 The Bronze Age metal cycle runs from raw material through casting, use, repair, and reuse to re-melting. Only loss, disposal, or intentional deposition led to the preservation of metalwork (axe from Călacea, Sălaj county, Romania, Muzeul Județean de Istorie şi Artă Zalău CC. 168/1976).

Abb. 7 *Der bronzezeitliche Metallkreislauf verläuft vom Rohmaterial über das Gießen, den Gebrauch, die Reparatur und die Wiederverwendung bis hin zum erneuten Einschmelzen. Nur Verlust, Entsorgung oder die intentionelle Deponierung führen zur Erhaltung von Metallgegenständen (Beil aus Călacea, Kr. Sălaj, Rumänien, Muzeul Județean de Istorie şi Artă Zalău CC. 168/1976).*

Fig. 8 Main types of early socketed axes (18th–16th centuries BC) from the Carpathian Basin. Most numerous are the variations of curved or rather angular axes with a short, straight, or slanting beak, but also a type of the »Transylvanian« facetted axes occurs. Finds from Romania (left to right: Ciumeşti, Satu Mare county, Muzeul Județean Satu Mare, 41409; Glod county, Maramureş, Muzeul Județean de Istorie şi Arheologie Baia Mare, 234; Ciumeşti, Satu Mare county, Romania, Muzeul Naţional de Istorie a României, Bucureşti, 69645; Sebeş, Alba county, Muzeul Național al Unirii din Alba Iulia, 7670).

Abb. 8 *Haupttypen der frühen Tüllenbeile (18.–16. Jh. v. Chr.) aus dem Karpatenbecken. Am häufigsten sind leicht geschwungene oder eckige Varianten von Schnabeltüllenbeilen, jedoch kann auch ein Typ der »Siebenbürgischen« facettierten Beile frühdatiert werden. Funde aus Rumänien (von links nach rechts: Ciumeşti, Kr. Satu Mare, Muzeul Județean Satu Mare, 41409; Glod, Kr. Maramureş, Muzeul Județean de Istorie şi Arheologie Baia Mare, 234; Ciumeşti, Kr. Satu Mare, Romania, Muzeul Național de Istorie a României, Bucureşti, 69645; Sebeş, Kr. Alba, Muzeul Național al Unirii din Alba Iulia, 7670).*

the later periods (Mozsolics 1967; David 2002, 399–416; Soroceanu 2012). These finds usually contain few objects, rarely exceeding 15–20 items. The range of artefacts is focused on weapons and jewellery; tools are rare. The weapons, mostly swords and axes, are individualised with rich and unique decorations. In combination with occasionally »matching« numbers of weapons and jewellery, they often give the impression of personal equipment with a martial character. At the beginning of the Late Bronze Age, this pattern changed. Hoards became larger and more diverse in terms of content, now including a wide range of artefact groups, particularly tools; until the end of the hoarding custom at the beginning of the Iron Age, sickles and axes were the essential components of most hoards, along with rings and spearheads[16].

As a result of their non-inclusion in the social practice of hoarding, tools – and with them the early socketed axes– have survived primarily as rare settlement finds before the Late Bronze Age. Most of these settlement finds are not finished products, but casting moulds[17]. An important exception is the hoard of Perişor, Bistrița-Năsăud county, Romania (Soroceanu/Retegan 1981). Among other early items such as sickles (Dietrich 2010b), it contains several forms of socketed axes. The metalwork was found in a vessel of the classical Wietenberg Culture, which, according to radiocarbon data, can be placed between the middle of the 18th century and the first half of the 16th century BC (Bălan et al. 2016). They are thus among the earliest pieces of clear evidence for socketed axes in the Carpathian Basin so far. These early axes are not uniform from a typological point

16 Mozsolics 1973; Petrescu-Dîmbovița 1978; Mozsolics 1985; Hansen 1994; Mozsolics 2000; König 2004; Bratu 2009.

17 Dietrich 2011; Dietrich 2015; Dietrich 2021, 41–42; 109–131.

18 Types A3, A4, A4a: Dietrich 2021, 222–229.

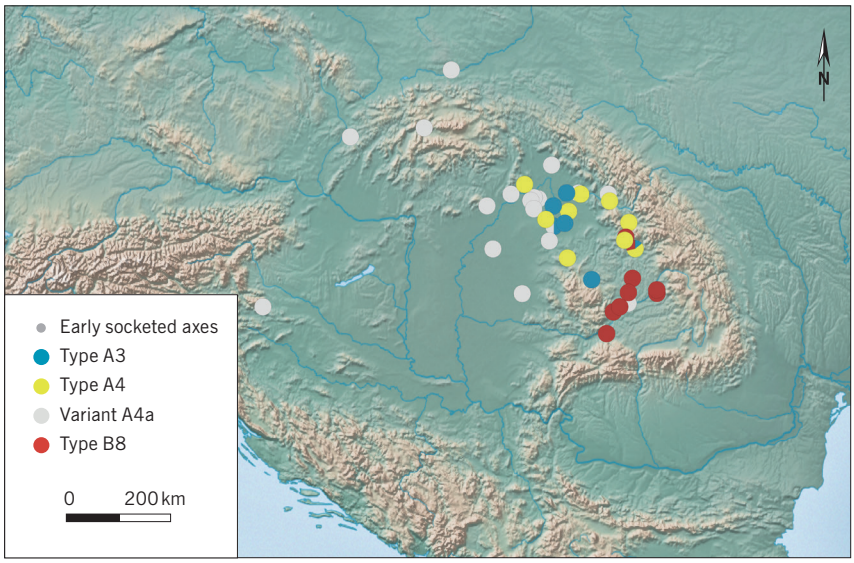

Fig. 9 Distribution of the main types of early socketed axes from the Carpathian Basin. Due to the formal and spatial differentiation, it would not be surprising if these were not actually the oldest socketed axes in this region. References in Dietrich 2021.

Abb. 9 *Verbreitung der Haupttypen früher Tüllenbeile aus dem Karpatenbecken. Aufgrund ihrer formalen und räumlichen Differenzierung wäre es nicht verwunderlich, wenn es sich dabei nicht um die ältesten Tüllenbeile dieser Region handeln würde. Nachweise in Dietrich 2021.*

of view (Fig. 8). Most numerous are the variations of curved or rather angular axes with a short, straight, or slanting beak[18], but also a type of the »Transylvanian« facetted axes occurs[19]. Due to the formal[20] and spatial[21] (Fig. 9) differentiation, it would not be surprising if these were not actually the oldest socketed axes. A mould fragment from the Early Bronze Age[22] »foundry house« of Feudvar, near Mošorin, Vojvodina, Serbia predates them clearly, although a final determination between an axe or a chisel is hard to make (Hänsel/Medović 2004, 97 Fig. 8,5; 14,3–4). Numerous casting cores prove that there was a massive manufacture of socketed implements in the Early Bronze Age at the site (Hänsel/Medović 2004, 101–102).

Socketed axes, an eastern or western innovation?

Since the Late Bronze Age can thus be ruled out as the time of the invention of socketed axes, the question of the origin of the tool type and the idea of casting socketed axes must be re-approached. So far, the earliest mass-produced and radiocarbon dated socketed axes in Eurasia come from the so-called Seima-Turbino horizon (Fig. 10), a group of metal implements mainly distributed between the Yenisei and the area west of the middle reaches of the Volga (Černych/Kuzminykh 1989; Černych 1992; Fricke 2018), with the hoard from Borodino, Odessa oblast, Ukraine, as the possible westernmost find in the Black Sea area (Kaiser 1997).

E. Černych (1992, 216) listed 422 finished metal products and 30 moulds from the vast distribution area of the Seima-Turbino horizon, most of which came from cemeteries. The grave goods in the form of spearheads, knives, socketed axes, bone lamellae of protective weapons and greenstone jewellery were interpreted as expressions of warrior identities. Some tombs are seen as burials of metalworkers due to presence of casting moulds. The socketed axes play an important role in this display of social identities. Pottery is mostly absent from the graves, though. It is therefore difficult to link the Seima-Turbino bronzes to archaeological cultures, leading to the concept of a »transcultural« Seima-Turbino package of mostly high-status bronze objects and new casting technologies spreading across the Eurasian steppes by westward migrating groups. Besides the burial grounds, another type of Seima-Turbino site has become known in recent years. Shaitanskoe Ozero II, near Neivo-Rudyanka, Sverdlovsk oblast, Russia, is a deposition site on a lakeshore, where more than 200 bronzes and local ceramics have been found (Serikov et al. 2009). The Seima-Turbino horizon had long been dated to the 16th and 15th centuries BC, based on comparisons with Mycenaean finds (Kaiser 1997); however, recent radiocarbon dates point to a date range between about 2200/2000 and 1800 cal BC (Fricke 2018), and contact chronology with Chinese finds may indicate a slightly later date (Grigoriev 2023). This would be chronologically close to the early socketed implements in the Carpathian Basin, but direct contact finds are absent. Of

19 Type B8: Dietrich 2021, 405–411.

20 There are further finds that could widen the range of early axe forms, but some of these finds would need in-depth study to verify find circumstances and dates: Celldömölk, Vas county, Hungary (Middle Bronze Age settlement find, casting mould: Wanzek 1989, 204 Nr. 69d; Pl. 49,8b), Soltvadkert, Bács-Kiskun county, Hungary (Middle Bronze Age settlement find, casting moulds, possibly for socketed hammers: Hänsel 1968, 73; Pl. 25,1–2; 4–5; 11–12) and Veselé, Trnavský region, Slovakia (Middle Bronze Age settlement find, casting mould: Bartík 1995, 43; 46 Fig. 4); Drevenik, Prešovský region, Slovakia (hoard: Forró horizon: Novotná 1970, 72–73, Nr. 467; 39, Nr. 226); Ožd´any, Banskobystrický region, Slovakia (hoard, Bz C2/D: Novotná 1970, 92–93 Nr. 711; Pl. 40,711); Szécsény, Nógrád county, Hungary (hoard, Forró horizon: Mozsolics 1973, 121), Transdanubia (hoard: Wanzek 1989, 136; Pl. 53,6).

21 Type A4 is more easterly distributed, variant A4a more westwardly, and type A3 occurs in both groups: Dietrich 2021, 222–229.

22 In Central European terminology; in some South-Eastern European chronology systems, the Vatina Culture would be addressed as Middle Bronze Age; Hänsel/Medović 1991, 71–72, date the occupation of Feudvar between Frühdanubisch III–Mitteldanubisch II, or, in absolute dates, 1900–1500 BC.

Fig. 10 So far, the earliest mass-produced socketed axes in Eurasia come from the so-called Seima-Turbino horizon, a group of metal implements mainly distributed between the Yenisei and the area west of the middle reaches of the Volga. Their contexts are radiocarbon dated between 2000–1800 BC. Socketed axes of the Seima-Turbino type from Shaitanskoe Ozero II, near Neivo-Rudyanka, Sverdlovsk oblast (Russia; The Nizhny Tagil Museum of Regional History; no inventory numbers).

Abb. 10 *Bisher stammen die frühesten in Serie hergestellten Tüllenbeile in Eurasien aus dem sogenannten Seima-Turbino-Komplex, einer Gruppe von Metallgeräten, die hauptsächlich zwischen dem Jenissei und dem Gebiet westlich des Mittellaufs der Wolga verbreitet ist. Radiokarbondaten verorten die Fundkontexte zwischen 2000 und 1800 v. Chr. Tüllenbeile vom Seima-Turbino-Typ aus Shaitanskoe Ozero II, in der Nähe von Neivo-Rudyanka, Oblast Swerdlowsk (Russland; Historisches Regionalmuseum Nischni Tagil; keine Inventarnummern).*

Find list 2: »Composite« socketed axes		
1.	**Azay-le-Rideau**	Dep. Indre-et-Loire, France. Single find, flanged axe with socket. Holste 1941, 158 Fig. 1; Cordier/Millotte 1961, 145–146 Fig. 3.
2.	**Borstel**	Segeberg district, Germany. Single find, flanged axe with socket. Aner 1962, 174 Fig. 4,1; Laux 2000, 85 Nr. 331; Pl. 21,331.
3.	**Czubin**	Masovian voivodeship, Poland. Hoard, period II (or III?), palstave with socket. Kuśnierz 1998, 70 Nr. 572; Pl. 26,572.
4.	**Dolní Sukolom**	Olomoucký region, Moravia. Hoard, older Urnfield period, palstave with socket. Říhovský 1992, 248 Nr. 979; Pl. 69,979.
5.	**Grödby**	Stockholms county, Sweden. Single find, palstave with socket. Aner 1962, 174.
6.	**Haarbølle**	Sjælland region, Denmark. Single find, palstave with socket. Aner 1962, 174 Fig. 4,3.
7.	**Hønsinge**	Sjælland region, Denmark. Grave, period II, flanged axe with socket. Aner 1962, 170 Fig. 1,3; 2,1.
8.	**Kütten-Drobitz**	Saalekreis district, Germany. Hoard, Únětice Culture, flanged axe with socket. Kossina 1925 (Cöthen); Sprockhoff 1941, Fig. 69,4 (Köthen); Billig 1957, 294–295 Fig. 6; v. Brunn 1959, 61–62; Pl. 57,2.
9.	**Lau myr**	Gotland district, Sweden. Single find, flanged axe with socket. Aner 1962, 170.
10.	**Łupice**	Lubusz voivodeship, Poland. Single find, palstave with socket. Kuśnierz 1998, 69–70 Nr. 571; Pl. 26,571 (Kuśnierz opts for a late date of this single find because of the »Lusatian ornaments« on it).
11.	**Mannarp**	Skåne county, Sweden. Hoard, period II, flanged axe with socket. Aner 1962, 170.
12.	**Obbornhofen**	Gießen district, Hessen, Germany. Hoard, Early Bronze Age, flanged axe with socket, lost. Kibbert 1984, 178–179 Nr. 908.
13.	**Rönneberga**	Stockholms county, Sweden. Single find, flanged axe with socket. Sprockhoff 1941, Pl. 7; Aner 1962, 170.
14.	**Salling**	Midtjylland region, Denmark. Single find, flanged axe with socket. Aner 1962, 174 Fig. 4,2.
15.	**Skelby**	Sjælland region, Denmark. Grave, period II, flanged axe with socket. Aner 1962, 170 Fig. 1,2.
16.	**Spandau**	Berlin, Germany. Hoard, period II, socketed axe with blade in the fashion of a flanged axe. Bohm 1935, 41; Pl. 13,16.
17.	**Wangford**	Suffolk, England, Great Britain. Single find, flanged axe with socket. Briscoe 1954; Gerloff 1975, 154–155, App. 4,59; Pl. 56H.
18.	**Westerwanna**	Cuxhaven district, Germany. Single find, flanged axe with socket. Laux 2000, 85–86 Nr. 332; Pl. 21,332.
19.	**Sălaj county**	Romania. Single find, flat axe with socket. Dietrich 2021, 703; Pl. 649,2891.

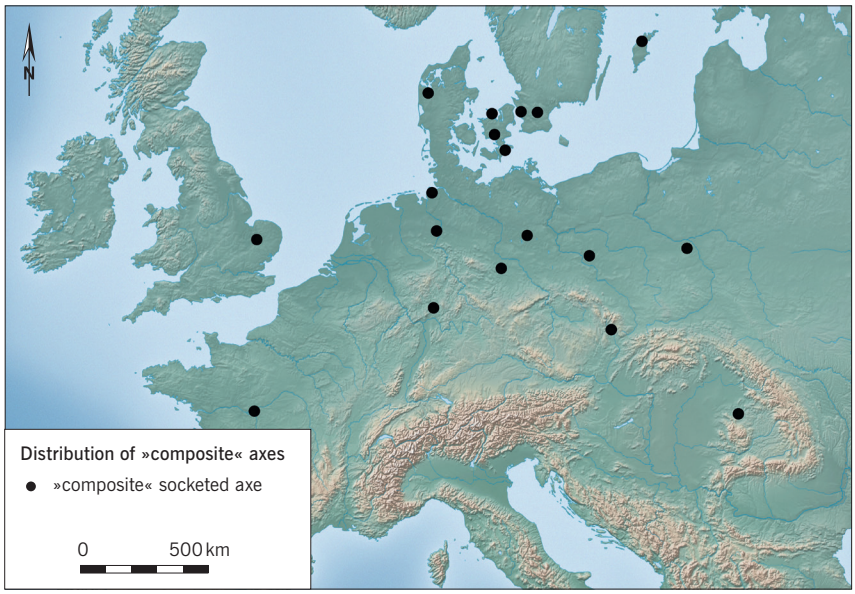

Fig. 11 Early socketed axes include experiments with sockets attached to other axe types. Such »composite socketed axes« are found most frequently in Scandinavia. They also appear in Central and Western Europe, although only rarely in the latter region. Distribution of »composite« socketed axes. References to findspots see Find list 2.

Abb. 11 *Unter den frühen Tüllenbeilen gibt es einige Experimente, bei denen Tüllen an andere Beilformen angesetzt wurden. Die meisten Funde stammen aus Skandinavien, doch gibt es auch Beispiele aus Mittel- und (selten) Westeuropa. Verbreitung der »zusammengesetzten« Tüllenbeile. Nachweise der Fundorte siehe Find list 2.*

Fig. 12 The Kütten-Drobitz I hoard, Saalekreis district (Germany), includes a »composite« socketed axe and a halberd. It belongs to the developed Únětice Culture, or Bz A2, making the axe a very early example. The side view of the axe shows a prominent casting seam that runs uninterruptedly from the socket to the body and as light set-off of the ribs, indicating casting in a two-part mould of the complete object. The parts of the mould shifted slightly during casting.

Abb. 12 *Der Hort von Kütten-Drobitz I, Saalekreis, enthält ein sehr frühes »zusammengesetztes« Tüllenbeil und eine Stabdolchklinge. Der Hort gehört in die entwickelte Aunjetitzer Kultur (Bz A2). Die Seitenansicht des Beils zeigt eine deutliche Gussnaht, die ohne Unterbrechung an Tülle und Beilkörper entlangläuft. Die leicht versetzten Rippen zeigen an, dass eine zweiteilige Gussform genutzt wurde, wobei sich die Formhälften leicht gegeneinander verschoben. Das Objekt ist in einem Stück gegossen.*

course, the idea of making socketed axes could have travelled, too (Dietrich 2015).

There are other centres of early innovation, though, which also have long-known and close connections with the Carpathian Basin. For the Nordic Circle, E. Aner outlined a group of flanged axes or palstaves dating to the (late) Period I and Period II with an added-on socket (List 2), on which thick ribs imitate a wrapping with wire or cord (Aner 1962). He saw the solid but movable bronze collars mentioned earlier as an intermediate step to these »composite« constructions. Such »composite socketed axes« are not exclusive to Scandinavia, though. They also appear in Central and Western Europe, although only rarely in the latter region (cf. List 2; Fig. 11). One of the earliest examples of such an axe comes from Saxony-Anhalt, Germany, particularly from the Kütten-Drobitz 1 (Saalekreis) hoard (Fig. 12)[23]. The socket

23 Kossinna 1925; Billig 1957, 294–295 Fig. 6; v. Brunn 1959, 61–62; Pl. 57,2; Kibbert 1984, 120; Meller 2013, 516.

of the axe is heavily ribbed and – like the Scandinavian examples – imitates a wrapping with cord. A small semi-oval prominence additionally indicates the end of the forked tenon. Associated with a halberd, it belongs to the developed Únětice Culture, or Bz A2. The side view of the Kütten axe shows a prominent casting seam that runs uninterruptedly from the socket to the body and a slight set-off of the ribs, indicating casting in a two-part mould of the complete object[24]. The parts of the moulds shifted slightly during casting. The socket may look like it was added to the axe blade, but the casting technique is already the one used for socketed axes throughout the Bonze Age. Most interestingly, the closest analogy comes from Great Britain, a flanged axe with an »added-on« socket from Wangford, Suffolk, England, dated by S. Gerloff (1975, 154–155, App. 4,59; Pl. 56H) to the Wessex Culture (Fig. 13). A strange and, so-far, unique socketed axe without a loop from the »Sălaj county« in Romania (Fig. 14) is comparable to both artefacts, with its strong ribs and a socket that gives the impression of being added to a flat axe (Dietrich 2021, 703; Pl. 649,2891). A flanged axe from Borrby, Skåne län, Sweden, could be another analogy (Fig. 15)[25]. It has a forked peg similar to Kütten, and the shaft is broken and hollow, giving the impression of a socket (Forssander 1940, 76–77 Fig. 1; Pl. 1); it could, however, also be a rendition of the »usual« hafting of flanged axes with forked pegs, like the axe from Przećmino mentioned above.

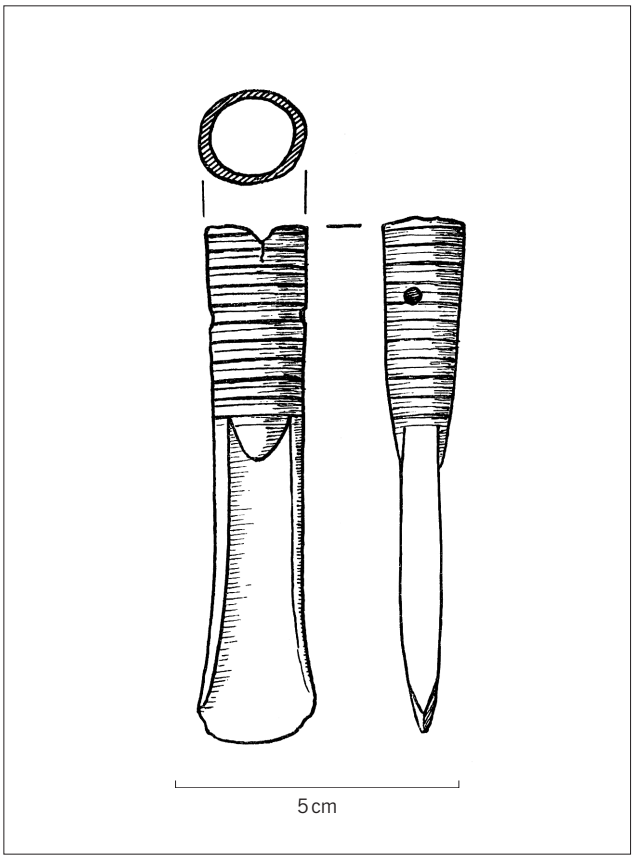

Fig. 13 The early socketed axe from Wangford, Suffolk (England), looks like a flanged axe with an added-on socket and dates to the Early Bronze Age Wessex Culture. It is very similar to the axe from Kütten-Drobitz.

Abb. 13 *Das frühe Tüllenbeil aus Wangford, Suffolk (England), wirkt wie ein Randleistenbeil mit angesetzter Tülle. Der Fund datiert in die frühbronzezeitliche Wessex-Kultur und ist dem Beil von Kütten-Drobitz sehr ähnlich.*

Fig. 14 A »composite« socketed axe from the Sălaj county in Romania is very similar to the finds from Kütten-Drobitz and Wangford with its strong ribs and a socket that gives the impression of being added to a flat axe (Muzeul Judeţean de Istorie şi Artă Zalău, CC. 791958).

Abb. 14 *Das »zusammengesetzte« Tüllenbeil aus dem Kr. Sălaj in Rumänien ist mit der starken Rippung und der Tülle, die wie auf ein Flachbeil aufgesetzt wirkt, den Beilen aus Kütten-Drobitz und Wangford formal verwandt (Muzeul Judeţean de Istorie şi Artă Zalău, CC. 791958).*

24 See already Billig 1957, 294–295 Fig. 6. This casting technique has to be reviewed in detail on the original finds; an investigation is planned for the near future.

25 See already Forssander 1940.

Fig. 15 The axe from Borrby, Skåne county (Sweden; no scale) has been cited as another example of an early »composite« socketed axe. It has a forked peg similar to Kütten-Drobitz, and the shaft is broken and hollow, giving the impression of a socket. It could, however, also be a rendition of the »usual« hafting of flanged axes with forked pegs, like the axe from Przećmino.

Abb. 15 *Das Beil aus Borrby, Prov. Skåne (Schweden; o. M.) wurde als weiterer Beleg für »zusammengesetzte« Tüllenbeile diskutiert. Die Gabelschäftung ist ähnlich zu dem Beil von Kütten-Drobitz, der Schaft ist gebrochen und wirkt tüllenartig. Es könnte sich allerdings auch um die »einfache« Umsetzung einer Gabelschäftung in Metall handeln, ähnlich dem Fund von Prettmin/Przećmino.*

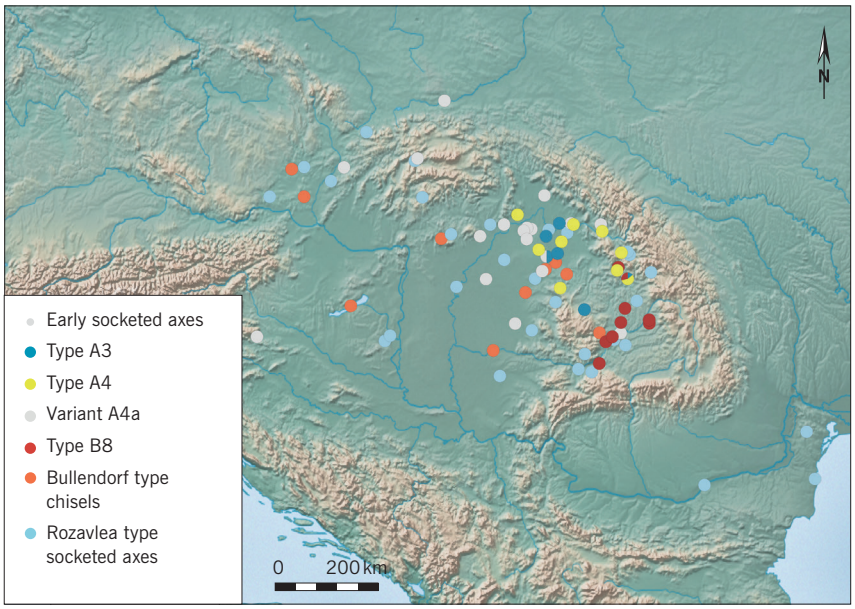

Fig. 16 Map showing the distribution of Bullendorf type chisels, socketed axes typologically similar to them, and the early socketed axe types of the Carpathian Basin. A dense area of Early to Middle Bronze Age experiments with the socket hafting technique emerges. It seems that the idea of making socketed axes spread fast in the Early Bronze Age – but its origin is not entirely clear at the moment.

Abb. 16 *Verbreitungskarte der Meißel vom Typ Bullendorf, der typologisch ähnlichen Tüllenbeile und der frühen Tüllenbeiltypen aus dem Karpatenbecken. Es zeigt sich ein dichtes Gebiet mit experimentellen Tüllenschäftungen aus der frühen bis mittleren Bronzezeit. Es scheint, dass sich die Tüllenbeilidee in der frühen Bronzezeit schnell verbreitete – ihr Ursprung ist derzeit nicht völlig klar.*

The early »composite« axes are typologically very similar to the Bullendorf type chisels of the Únětice Culture, the Carpathian Basin, and the neighbouring regions (cf. List 1). Kütten, Wangford, and Sălaj could easily be the earliest »composite socketed axes« known so far (cf. List 2). In any case, these »socket-experiments« are generally contemporaneous with the earliest horizon of socketed axes in the Carpathian Basin. If we map the Bullendorf type chisels, the socketed axes typologically similar to them, and the early socketed axes of the Carpathian Basin, a dense area of Early to Middle Bronze Age experiments with the new hafting technique emerges (Lists 1–3; Fig. 16), while the same innovation process is indicated further west by the »composite« socketed axes (cf. Fig. 11). It seems that the idea of making socketed axes (Sprockhoff´s »Tüllenbeilidee«, cf. Sprockhoff 1941, 115) spread fast in the Early Bronze Age, but its origin is not entirely clear at the moment. A spread from the east to the Carpathian Basin and further west, from the

Find list 3: Socketed axes of type A2 (Rozavlea)		
1.	**Alsódobsza**	Borsod-Abaúj-Zemplén county, Hungary. Hoard, Kurd horizon. Mozsolics 1985, 85–86; Pl. 166,3.
2.	**Anieş**	Bistrița-Năsăud county, Romania. Hoard, phase 4. Dietrich 2021, 195 Nr. 14.
3.	**Balmaújváros**	Hajdú-Bihar county, Hungary. Hoard, Hajdúböszörmény horizon. Mozsolics 2000, 34–35; Pl. 4,2.
4.	**Beliu**	Arad county, Romania. Single find. Dietrich 2021, 195 Nr. 15.
5.	**Blučina 18**	Brno-venkov district, Czech Republic. Hoard Blučina/Drslavice Ořechov horizon. Salaš 2005, 306 Nr. 18,1; Pl. 89,B1.
6.	**Bogdan Vodă**	Maramureş county, Romania. Hoard, main accumulation in the older Urnfield period. Dietrich 2021, 195–196 Nr. 16–17.
7.	**Bonyhád**	Tolna county, Hungary. Hoard, Kurd horizon. Mozsolics 1985, 102–104; Pl. 41,10.
8.	**Botpalád**	Szabolcs-Szatmár-Bereg county, Hungary. Hoard, »Berkesz-Kultur«: Kemenczei 1984, 124 Nr. 39; Pl. LVIIIa,3.
9.	**Cadea**	Bihor county, Romania. Unclear. Dietrich 2021, 196 Nr. 18.
10.	**Cetatea de Baltă**	Alba county, Romania. Unclear, Dietrich 2021, 196 Nr. 19.
11.	**Cugir**	Alba county, Romania. Hoard, phase 2. Dietrich 2021, 196 Nr. 20.
12.	**Detva**	Banskobystrický region, Slovakia. Hoard, Jászkarajenő horizon. Novotná 1970, 80 Nr. 556; Pl. 31,556.
13.	**Dipşa**	Bistrița-Năsăud county, Romania, Hoard, main accumulation in the older Urnfield period. Dietrich 2021, 196–197 Nr. 21.
14.	**Komjatná**	Žilinský region, Slovakia. Hoard, Kisapáti horizon. Novotná 1970, 80 Nr. 557; Pl. 31,557.
15.	**Limberg**	Lower Austria, Austria. Single find. Mayer 1977, 185 Nr. 977; Pl. 71,977.
16.	**»Moravia or eastern Hungary.«**	Říhovský 1992, 185 Nr. 662; Pl. 44,662; 200 Nr. 713; Pl. 48,713.
17.	**Oinacu**	Giurgiu county, Romania. Hoard, older Urnfield period. Dietrich 2021, 197–198 Nr. 22.
18.	**Olcsvaapáti II**	Szabolcs-Szatmár-Bereg county, Hungary. Hoard Ópályi horizon. Mozsolics 1973, 164; Pl. 34,5.
19.	**Pétervására**	Heves county, Hungary. Hoard, »Piliny-Kultur.« Kemenczei 1984, 119 Nr. 29b; Pl. LI,8.
20.	**Rapoltu Mare**	Hunedoara county, Romania. Hoard, phase 2. Dietrich 2021, 198 Nr. 23.
21.	**Rozavlea III**	Maramureş county, Romania. Hoard, phase 1. Dietrich 2021, 198–199 Nr. 24–31.
22.	**Sâmbăta Nouă II**	Tulcea county, Romania. Hoard, older Urnfield period. Dietrich 2021, 199 Nr. 32.
23.	**Sióagárd II**	Tolna county, Hungary. Hoard, Kurd horizon. Mozsolics 1985, 186; Pl. 43,1.
24.	**Skalica**	Trnavský region, Slovakia. Unclear. Novotná 1970, 81 Nr. 573; Pl. 32,573.
25.	**Slovakia**	Novotná 1970, 80 Nr. 551; Pl. 31,551.
26.	**Şpălnaca II**	Alba county, Romania. Hoard, main accumulation in the older Urnfield period. Dietrich 2021, 199–201 Nr. 33–34.
27.	**Štramberk 1**	Nový Jičín district, Czech Republic. Hoard, Younger Urnfield period. Salaš 2005, 454–455 Nr. 48.1b; Pl. 430,1b.
28.	**Şuncuiuş I**	Bihor county, Romania. Hoard, phase 1. Dietrich 2021, 201–202 Nr. 35.
29.	**Szolnok**	Jász-Nagykun-Szolnok county, Hungary. Hoard, Kurd horizon. Mozsolics 1985, 197–198; Pl. 221,4.
30.	**Techirghiol**	Constanța county, Romania. Hoard, phase 2. Dietrich 2021, 202 Nr. 36.
31.	**Timişoara**	Timiş county, Romania. Unclear. Dietrich 2021, 202 Nr. 37.
32.	**Uioara de Sus**	Alba county, Romania. Hoard, main accumulation in the older Urnfield period. Dietrich 2021, 202–203 Nr. 38–40.
33.	**Zlatna III**	Alba county, Romania. Hoard, older Urnfield period. Dietrich 2021, 203–204 Nr. 41

Únětice area to the Carpathian Basin, or an invention in the Carpathian Basin are all conceivable. What we see, in any case, is an Early Bronze Age »innovation horizon« throughout Europe that breaks completely with the traditional shapes of axes known so far. In Central and Northern Europe this development initially appears to have had no immediate consequences. The Únětice area continued using the flanged axes, the Nordic Circle stuck for some more time with their palstaves. The Carpathian Basin, on the other hand, was an »early adopter.« Compared to the relatively few early axes from these regions, the evidence from the eastern steppes seems massive. This is due to the social value of the axes in the Seima-Turbino area, where they are important grave goods. In Scandinavia, some of

Fig. 17 Two trends can be observed within the history of hoarding axes during the Bronze Age of the Carpathian Basin. Axes, particularly socketed axes, are constantly becoming more important in hoards; there are fewer and fewer hoards without them. Also, the socketed axes become smaller. At the transition to the Iron Age, genuine miniature axes can be found in the few hoards that are still known in the Carpathian Basin. Miniature socketed axe from the hoard of Crizbav, Braşov county (Romania; Muzeul Naţional Militar, Bucureşti, 3575-C509).

Abb. 17 *Zwei Trends prägen die Geschichte der Hortung von Beilen in der Bronzezeit des Karpatenbeckens. Beile, besonders Tüllenbeile, gewinnen in Hortfunden immer mehr an Bedeutung; es gibt immer weniger Horte ohne sie. Außerdem werden die Tüllenbeile kleiner. Am Übergang zur Eisenzeit finden sich in den wenigen noch bekannten Horten im Karpatenbecken regelrechte Miniaturbeile. Miniaturtüllenbeil aus dem Hort von Crizbav, Kr. Braşov (Rumänien; Muzeul Naţional Militar, Bucureşti, 3575-C509).*

Fig. 18 From mound 1 of the Lăpuş burial ground, Maramureş county (Romania), comes one of the earliest (if not the earliest) iron socketed axes in South-Eastern Europe. The mound is dated to the Lăpuş 1 phase, which corresponds to the early Urnfield period. Interestingly, a closed socket renders the axe unusable, giving the impression of a failed attempt probably indicating the experimental phase when beginning to work with a new material and a new manufacturing technique – forging (Muzeul Naţional de Istorie a României, Bucureşti, 69739).

Abb. 18 *Aus Hügel 1 des Gräberfelds von Lăpuş, Kr. Maramureş (Rumänien), stammt ein eisernes Tüllenbeil, möglicherweise das älteste bekannte in Südosteuropa. Der Hügel wird in die Phase Lăpuş 1 datiert, die der frühen Urnenfelderzeit entspricht. Interessanterweise macht eine verschlossene Tülle das Beil unbrauchbar. Es entsteht der Eindruck eines gescheiterten Versuchs, was wahrscheinlich auf die experimentelle Phase hindeutet, in der begonnen wurde, mit Eisen als neuem Material und einer neuen Herstellungstechnik zu arbeiten – dem Schmieden (Muzeul Naţional de Istorie a României, Bucureşti, 69739).*

the early »socket-experiments« are included in grave inventories and hoards, while the early history of this axe type in Central and South-Eastern Europe is obscured by their overall non-inclusion in depositions during the Early and Middle Bronze Age.

Archaeologically invisible again: The last bronze and first iron axes

The history of the earliest socketed axes shows how closely their archaeological visibility can be linked to social practices – in this case, hoarding or grave goods. If we look at the history of hoarding axes in the Carpathian Basin in the *longue durée*, two trends can be observed throughout the Bronze Age. On the one hand, axes, particularly socketed axes, are constantly becoming more important in hoards; there are fewer and fewer hoards without them (Soroceanu/Lakó 1995, 191; Tab. 1; Bratu 2009, 60–61 Fig. 34). On the other hand, the socketed axes become smaller (König 2004, 35 Fig. 5; Dietrich 2021, 149 Fig. 7,8). At the transition to the Iron Age, genuine miniature axes can be found in the few hoards that are still known in the Carpathian Basin (Dietrich 2021, 528–531; 535; 771; Fig. 17). The alloy of late socketed axes often also contains only a small amount of tin (Kacsó 2013, 232; Pare 2019). At the end of the Bronze Age,

socketed axes become votives that no longer serve any function as tools or weapons.

During the phase of miniaturisation of bronze axes, iron axes were already widespread and took over the role of tools in everyday life. At first, socketed axes were made of iron – the successful type of Bronze Age tool was continued. One of the earliest (if not the earliest) iron socketed axes comes from mound 1 of the Lăpuş burial ground in Romania in South-Eastern Europe (Fig. 18)[26]. The mound is dated to the Lăpuş 1 phase, which corresponds to the early Urnfield period (Kacsó 2001). The axe lay on a burnt clay platform, which the excavator, C. Kacsó, identified as a possible cremation site. It is a socketed axe without a loop; the socket is partially closed. The cutting edge is damaged, as is the surface. Partly due to the state of preservation, this find is difficult to locate within the world of shapes of Bronze Age axes. The lack of a loop is unusual for the region but may be due to the manufacturing technique, as it would have been difficult to form or attach by forging. What is striking is the bending of the piece, which can hardly have been caused by use, as the closed socket renders the axe unusable. Overall, the axe gives the impression of a failed attempt and could indicate the experimental phase when beginning to work with a new material and a new manufacturing technique.

The early or experimental phase highlighted by the Lăpuş axe was followed by the regular imitation of bronze forms in iron. Since the 9th century BC at the latest, socketed axes with slotted sockets spread throughout South-Eastern Europe (Teržan 2017, 120–127 Fig. 5; List 1). Lugged axes, whose early bronze cousins date into the 2nd millennium in South-Western Asia (Wesse 1990, 61–64), are the second important iron axe type of this period (Wesse 1990, 143–168). They dominate the Hallstatt period in South-Eastern and Eastern Europe alongside the iron socketed axes and have come down to us in similar numbers. They in turn represent an innovation that fully exploits the possibilities of metal as a material. However, during the La Tène period they were replaced by iron socketed axes. The socket proves to be a very long-lasting innovation in axe technology.

The numerically low occurrence of iron axes in Southeastern Europe is probably linked to the end of the hoarding custom. The number of hoards drops continuously from Ha B1 onwards (Bratu 2009). In addition, hoards consisted almost exclusively of bronze objects until the end. Most of the iron socketed and lugged axes of the 9th to 8th century BC are settlement or individual finds in the Carpathian Basin[27]. The more numerous finds from the Eastern Hallstatt region, on the other hand, come from graves and can be interpreted as part of the weaponry of warriors. The overall small number of iron axes can hardly reflect prehistoric realities, in which the axe naturally remained of fundamental importance. Rather, once again the social practice of handling axes, the selection for hoarding or as grave goods, and their social value determines their archaeological visibility.

Conclusion

The secure attachment of axeheads to a wooden shaft has been a continuous problem since the switch to thin metal axeheads during the Chalcolithic and Early Bronze Age. The whole history of Bronze Age metal axes can be described as a process of innovation. Flanged axes, palstaves, and winged axes are attempts to construct axe bodies that can be securely attached to hafts with mounts in the form of forked pegs. Diverse solutions were experimentally sought and applied already during the Early Bronze Age, with different hafting methods becoming the standard in different parts of Europe. Cultural norms of what was perceived as functional seem to have at least partly determined predilections for certain axe types. This is exemplified by an in-depth look at the history of socketed axes, which appear – contrary to current assumptions – not suddenly in the Late, but already in the Early Bronze Age. The socketed axehead is the most viable way of attaching axes to hafts: The axehead holds securely and does not necessitate the problematic forked peg anymore.

The history of the socketed axe also shows how much the archaeological visibility of the development of Bronze Age axes depends on their social value. In parts of Central and South-Eastern Europe, axes are mostly discovered as parts of hoards. In periods in which the hoarding custom decreases or axes are not among the object categories chosen for hoarding, their visibility rapidly declines and evidence is mostly limited to settlement finds, often of casting mould fragments. The massive early evidence for socketed axes from the Seima-Turbino area, on the other hand, is due to their role as important grave goods. At the start of the Iron Age, hoards begin to disappear in South-Eastern Europe; here axes are, contrary to the regions further west, not included in graves. Again, evidence is reduced to settlement and single finds. For socketed axes, their inclusion in or exclusion from social practices and the differing social value attached to them hinders the visibility of their early and late history. It is therefore of paramount importance to include source-critical observations when writing a history of innovations based on archaeological evidence.

26 Kacsó 1975, 67 Fig. 1,16; Kacsó 2011, 356; Dietrich 2021, 761–762 Fig. 10,8.

27 For the socketed axes: Teržan 2017; Dietrich 2021, 761–763. For the lugged axes: Wesse 1990, 143–168. Her catalogue (Wesse 1990, 185–207) shows an interesting discrepancy. The more numerous finds from the Pannonian plain and the south-eastern Alpine region come from graves, whereas the Carpatho-Danubian region is characterised by isolated settlement finds but very few hoard finds.

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Bislang erschienene Bände in der Reihe »Tagungen des Landesmuseums für Vorgeschichte Halle«

Die Reihe der Tagungsbände des Landesmuseums wurde 2008 ins Leben gerufen. Anlass dazu war die Konferenz »Luthers Lebenswelten«, die im Jahr 2007 in Halle (Saale) ausgerichtet wurde. Bereits der zweite Tagungsband widmete sich mit dem Thema »Schlachtfeldarchäologie« dem Mitteldeutschen Archäologentag, der seit 2008 jährlich vom Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt veranstaltet und zeitnah publiziert wird. Dem großen Anteil internationaler Autorinnen und Autoren entsprechend, erscheinen viele Beiträge dieser Reihe in englischer Sprache mit deutscher Zusammenfassung.

Mit dem zuletzt erschienenen Tagungsband konnten die Vorträge der Internationalen Konferenz »Aspekte magischen Denkens« in zahlreichen Artikeln renommierter Forscher verschiedenster Fachdisziplinen vorgelegt werden.

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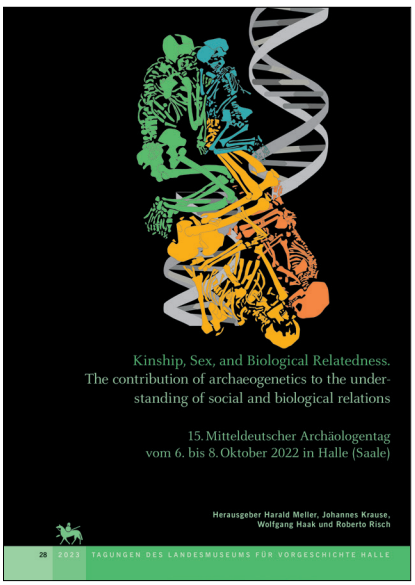

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